WOODPECKER ABUNDANCE AND NEST-HABITAT IN A MANAGED BALSAM FIR ECOSYSTEM

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WOODPECKER ABUNDANCE AND NEST-HABITAT IN A MANAGED BALSAM FIR ECOSYSTEM

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Abstract

Much of the balsam fir forest of western Newfoundland is limited to a 60-year timber harvest rotation, resulting in limitations on the amount of potential woodpecker habitat available in the later successional stages of these forests. The abundance of and nest-habitats of black-backed, downy, and hairy woodpeckers were quantified in 40-, 60-, and 80+-year-old balsam fir forests in western Newfoundland.

There were no significant differences in abundance among forest age-classes, but there has been a consistent trend for black-backed woodpeckers to be found in the oldest age class forests available throughout their range, and almost exclusively in the 80+-year-old balsam fir forests in western Newfoundland. Downy woodpeckers were more abundant and were equally distributed among the three age classes. Hairy woodpeckers were scarce and only found in the 40- and 60-year-old age classes. An extensive 60-year harvest rotation balsam fir timber management regime is reducing the habitat available for black-backed woodpeckers. Downy and hairy woodpeckers are associated more with the hardwood components of mixed stands, so they will most likely be unaffected by the loss of later successional stages of balsam fir stands.

Woodpeckers have historically shown greater use of older forests because there was a greater density of cavity-trees in 80+-year-old forests than in 40-, and 60-year-old forests. The mean diameter of cavity-trees was within the upper 25% of the diameter classes of trees found among the three age classes. The diameter of cavity-trees in the older forests was two diameter classes larger than in the younger forests. The diameter of active nest-trees were within the upper 5% of the diameter classes of trees found among the three age classes.

All woodpeckers were found at nest-sites surrounded by a mean density of trees approximately 50% less than found in 40-year-old forests, and 25% less than found in 60-, and 80+-year-old balsam fir forests. Canopy cover was equally sparse, and tree height surrounding nest-sites was shorter than that found in all forest age classes. There were no differences in mean tree diameter at breast height between trees surrounding nest-sites and

those within 40-, 60-, and 80^{+}-year old forests. Blowdowns and small defoliated areas, that occur primarily in later successional stages of balsam fir forests, accounted for the majority of nest sites found. Black-backed woodpeckers are particularly vulnerable to loss of nest-habitat as they were choosing nest-sites in conifer trees and are associated with conifer-dominated forests. Downy and hairy woodpeckers occupied a variety of nest-sites from remnant white birch snags in clearcuts, to rotting balsam fir snags in dense forest. They therefore may be able to persist under a short-rotation timber management regime as long as there is a residual hardwood component in the forests.

Future research is needed only to improve the precision of the definition of habitat selection by woodpeckers. Managers should assume that eradication of older balsam fir forests adversely affects woodpecker populations and habitat, and should plan for inclusion of these stands at the landscape-level to avoid ecosystem deterioration and habitat loss. An incorporation of forest-growth projection models with spatial and temporal habitat variables will provide insight for woodpecker habitat management

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1. WILDLIFE HABITAT RELATIONSHIPS IN BOREAL FORESTS

1.1 ECOSYSTEM STRUCTURE AND ANIMAL DISTRIBUTION

A forest ecosystem is defined by spatial and temporal compositions of dynamic processes of forest succession, nutrient cycling and animal population dynamics. Composition can be influenced by structural features such as vegetation types, patch size and the connectivity of habitat types (Kimmins 1987; Noss 1990). Forest ecosystems are shaped by disturbances that occur at three different spatial and temporal scales (Haila et al. 1994). Glacial cycles occur over many thousands of years on a continental scale and play the ultimate role in the formation of landscape features, soil types and resulting vegetational features. Forest floristic successions occur over hundreds of years on a scale from tens to millions of hectares and follow regular major disturbances such as insect infestations or fire. Small-scale events, or mosaic processes (Whittaker and Levin 1977) within forest stands create micro-habitats that may be suitable for different species (Haila 1994). Processes such as the death of a tree or group of trees, and variation in forest undergrowth due to small canopy openings operate on spatial scales from cubic centimetres to several hectares and on temporal scales of days to decades (Haila et al. 1994). A landscape is thus defined as a "mosaic of habitat patches in which a particular patch (i.e., a 'focal' patch) is embedded" (Dunning et al. 1992: 169).

Organisms depend on the distribution and availability of food, cover and water for survival and reproduction (Mannan et al. 1994). The spatial and temporal arrangement of these resources define an organism's habitat. A species may show preference for certain habitat types, and as populations expand there may be a concurrent expansion in use of different habitat types (Rosenzweig 1991). Therefore, habitat choice is affected by population levels and the spatial and temporal distribution and abundance of habitat types and disturbances. These patterns could determine the sustainability and diversity of wildlife communities (Anderson and Gutzwiller 1994). It also seems plausible that the species using

different forest habitats vary with the age and stability of that habitat (Pulliam et al. 1992; Haila et al. 1994). For example, in the boreal forest of Finland, early forest stages are often populated by more open-habitat, pioneering birds, while the older and more stable stages are populated by year-round residents that are adapted to more permanent habitats (Haila et al. 1994). Some resident boreal forest organisms may complete their entire life cycle in one habitat without influence from surrounding areas, while others may use several different habitats that are affected by landscape-scale influences (Hansson 1992).

1.2 THE MANAGED ECOSYSTEM

Managed ecosystems are under continual structural change which create new regional patterns that organisms must respond to if they are to survive and reproduce (Holling 1988). Differences between natural forest ecosystems and ones managed for resource extraction may be that very large patches are missing in both the mature and clearcut stages of the managed forests. This change in landscape-scale structure may have effects on sparse and specialized species (Hansson 1992). Most areas on earth have been significantly influenced and degraded by human activity to the point where many habitats no longer function at their "biological potential" (Schamberger 1988).

The basic qualitative ecology of the boreal forest ecosystem is well understood, but sufficient knowledge of the processes regulating species distribution and abundance is still inadequate (Haila 1994). Quantitative indicators of ecosystem conditions must be developed in order to make comparisons of human-induced effects within and between different ecosystems. Knowledge must be gained about trade-offs between forest management practices with ecological integrity and wildlife conservation. If we are to better understand the effects of landscape management on wildlife populations, then we need to better understand the mechanisms of habitat selection rather than just measure habitat use. Furthermore, as well as studying the effects of forest management on animal habitat, it is important to determine the

relationship and differences between natural and human-induced environmental changes (Haila et al. 1994).

1.3 BALSAM FIR FORESTS OF NEWFOUNDLAND

Successional and mosaic processes are continual disturbances that play a role in the shaping of the boreal forest ecosystem. Infestations by the eastern hemlock looper (*Lambdina fiscellaria fiscellaria*) or eastern spruce budworm (*Choristoneura fumiferana*), rather than fire (Alexander and Euler 1981), are the primary factors of balsam fir (*Abies balsamea*) forest succession on insular Newfoundland (Thompson 1994). Unlike many boreal forest types, post-disturbance balsam fir boreal forest is self-perpetuating without any major intermediate vegetational successional types. Following a major insect infestation, balsam fir regeneration is typically very dense with 25,000–30,000 stems/ha. By 40 years, stem density is reduced to approximately 2500 stems/ha, and further reduced to 1600 stems/ha by 60 years (Thompson 1994). Trees do not usually live beyond 100 years; at 90 years a significant proportion of stands show signs of heart rot (Harlow et al. 1978; Whitney 1989).

Balsam fir is a cold-climate tree that grows well on moist, moderately drained soils. It is a medium-sized tree typically 12 to 18 m in height (Harlow et al. 1978), but can grow to 20-24 m at 70-100 years on productive sites (Flight and Peters 1992). It is the most abundant tree on insular Newfoundland with forests in the western region composed primarily of pure balsam fir mixed occasionally with white spruce (*Picea glauca*) and black spruce (*P. mariana*), white birch (*Betula papyrifera*) and eastern larch (*Larix laricina*) (Damman 1983). The western Newfoundland lowlands offer the best growing conditions for forests on the island. The amount of rainfall which limits the natural occurrence of fire, and the deep, well stratified soils account for the predominance of pure balsam fir stands in this area (Damman 1983).

1.3.1 Timber Management in Newfoundland

Following forest clearings, the success rate of natural regeneration is typically 90% in the western region of the island (Flight and Peters 1992), thus pre-commercial thinning by year 15 following clearcutting is the common tending method for early stand improvement. Due primarily to early stand break-up and the short life-span of balsam fir trees (Harlow et al. 1978), pulpwood harvest rotation is typically limited to 60 years. A 60-year harvest rotation has been established partly because older balsam fir stands are subject to insect defoliation, and increased volume loss by windfall that results from root and butt decay that weakens the trees (Whitney 1989; G. Warren, pers. comm., Can. for. Serv. 13 Jan. 1994); and partly because 60 years is the age of wood currently available. Industrial-scale pulpwood harvesting has occurred in western Newfoundland forests since 1925 when the pulp mill was established at Corner Brook. A pulpwood harvest typically removes all merchantable trees within cut blocks. However, white birch is typically left standing as this species is not used for pulp, thus accounting for some old, large white birch stems remaining in second-growth stands.

Five million hectares (45% of the total land area) of insular Newfoundland are forested, of which 2.8 million ha are considered 'productive,' i.e., producing $\geq$ 35 m^3/ha of timber (Milne 1991; Flight and Peters 1992). Control of 63% of productive forest land in Newfoundland is by two pulp and paper companies (Flight and Peters 1992). Some of the only wildlife-related timber-management considerations (not regulations) in timber harvest operations are that 5–10 stems/ha $\geq$15 cm, at least 2 m high, any species, in any condition, remain standing on a clearcut site. Another wildlife-related consideration is that 20 m wide non-harvest zones be placed along the edges of any waterway that are shown on 1:50,000 topographic map sheets (M. Lawlor, pers. comm., Nfld. For. Serv., 18 April 1996). Given the extent of land under potential timber management, it has now become as important to maintain habitat diversity, water quality and aesthetic values, as it is to maintaining a sustainable timber supply.

Timber managers now must face the challenge of developing management plans for sustained habitat supply for the maintenance and preservation of wildlife species diversity and

the demand for a sustainable supply of timber. Clarifications must be made of trade-offs between timber management and wildlife habitat, with information about the types of habitat affected by management decisions. Developing an understanding of the effects of forest management practices on wildlife requires a study of the diversity, distribution, and abundance of animals in undisturbed areas. Comparisons can be made between habitat types and among habitats at different levels and timing of exploitation. Through the study of undisturbed ecosystems we have found that timber management often excludes many of the life requirements for many forest-dwelling species (Angelstam and Mikusinski 1994). Therefore, knowledge of natural patterns gives a standard by which variation in animal abundance and distribution in human-modified environments can be gauged (Haila 1994).

1.4 BIRDS AS INDICATORS OF THE EFFECTS OF FOREST HARVESTING

Tree-cavity-nesting species have been used as indicators of the effects of tree harvesting strategies on wildlife (Carey 1983*b*; Bull et al. 1990). Woodpeckers in particular make good indicators of the effects of timber management practices because they are resident bird species that depend on habitat properties that often conflict with timber harvest objectives. Timber management has the potential to reduce habitat quality for cavity-nesting birds by removing potential nest-sites through harvesting and thinning or removal of snags for safety reasons. This can result in long-lasting changes in forest structure, leaving little habitat for primary and secondary cavity-nesting, snag-dependent species (Welsh and Capen 1992). Woodpeckers also forage on insects found in dead or dying wood, and for some species home ranges are typically associated with large old-growth areas (Angelstam and Mikusinski 1994).

1.5 PRESENT STUDY

1.5.1 Study Species

There are four primary cavity-excavating bird species in Newfoundland forests: black-backed (*Picoides arcticus*), three-toed (*P. tridactylus*), downy (*P. pubescens*), and hairy (*P. villosus*) woodpeckers. Northern flickers (*Colaptes auratus*) are also found on the island but are associated with clearings and edges. Yellow-bellied sapsuckers (*Sphyrapicus varius*) are very uncommon (Mactavish et al. 1989), and found only in hardwood areas of southwestern Newfoundland.

Both black-backed and three-toed woodpeckers are found in spruce forest while the latter prefer spruce, the former occur more frequently in pines and other conifers more typical of lower elevations and latitudes (Bock and Bock 1974). Black-backed woodpeckers are typically rare throughout their range, but may become locally common in recently burned forests (Villard and Beninger 1993; Villard 1994; Hutto 1995). Black-backed woodpeckers are more common than three-toed woodpeckers in eastern North America, often out-numbering the latter by 19:1 during irruptive years when abundances increase by an order of magnitude (Yunick 1985). Home-range sizes have been measured at 325, 120 and 70 ha in lodgepole pine on the eastern slopes of the Cascade Mountains in Oregon (Goggans et al. 1988), and 30 ha in conifer forests of the northeastern United States (Evans and Conner 1979). Home-range sizes for three-toed woodpeckers were 300, 140 and 50 ha in mixed conifer-lodgepole pine on the eastern slopes of the Cascade Mountains in Oregon (Goggans et al. 1988; Goggans n.d.), 30 ha in conifer forests of the northeastern United States (Evans and Conner 1979), and a winter territory size of 5.5–8 ha was found in Norwegian coniferous forest (Hogstad 1970). Black-backed and three-toed woodpeckers excavate for larval wood-boring insects, and flake off bark (scaling) of dead or dying trees (especially spruce) in search of insects (Short 1982; pers obs.).

Downy and hairy woodpeckers are common throughout the forested portions of insular Newfoundland. Downy woodpeckers are restricted to areas of moist deciduous growth in

mixed-coniferous forests (Short 1982). In Newfoundland balsam fir forests, they are typically associated with white birch trees. Winter territory sizes ranged from 2.1–7.7 ha in hardwood forests of Ohio (Matthysen et al. 1993). Downy woodpeckers forage chiefly by gleaning and peering-and-poking into bark irregularities, rarely excavating (Short 1982; Peters and Grubb 1983), thus obtaining a variety of insect foods. Hairy woodpeckers occupy a diversity of habitats in various hardwood and conifer forests in the east (Short 1982). Home-range averages 8 ha in size in the northeastern United States (Evans and Conner 1979). Hairy woodpeckers also glean and peer-and-poke for food items, but excavate for larval wood-boring insects more often than do downy woodpeckers (Short 1982; pers. obs.).

1.5.2 Study Objectives

While it would be ideal to experiment with landscape composition to study the effects of movement, social behaviour, and reproductive success and survival, it is difficult to study species on a landscape scale that have a sparse distribution and are wide-ranging (Hansson 1992). This study is therefore limited to stand-scale effects and comparisons between stands distributed throughout western Newfoundland balsam fir forest. The kinds of questions asked in this study provide insight into the present distribution of woodpeckers in balsam fir forests, and the possible effects on this distribution in a managed forest ecosystem.

In western Newfoundland, black-backed and three-toed woodpeckers appeared to be most abundant in 80*-year-old balsam fir stands (Hogan 1997). It seems plausible that short harvest rotations or specific harvest practices of intensive forest management may affect the distribution and availability of crucial woodpecker habitat in Newfoundland. Consequently, black-backed and three-toed woodpeckers could serve as indicators of the effects of forest harvesting on wildlife diversity and availability of suitable habitat in western Newfoundland. Therefore a primary objective was to determine the relative abundance of woodpeckers among 40-, 60- and 80*-year-old balsam fir forests in western Newfoundland. Comparisons of woodpecker abundance in Newfoundland with other northeastern North American forests

and similar forest types in Scandinavia, will provide better insight about the diversity of woodpecker habitat relationships.

Nest-tree characteristics and habitat features associated with nest-sites need to be identified and quantified in order to ensure the continued existence of cavity-nesting species in managed forest environments. Therefore, another objective was to determine if there will be suitable nesting habitat structures for breeding woodpeckers in a 60-year even-aged harvest rotation.

2. WOODPECKER ABUNDANCE IN DIFFERENT-AGED BALSAM FIR FORESTS IN WESTERN NEWFOUNDLAND

2.1 INTRODUCTION

Sixty-year pulpwood harvest rotations in western Newfoundland limit the age classes available as woodpecker habitat. This may have an effect on woodpecker populations, as there is some indication that black-backed and three-toed woodpeckers were more common in 80^{+}-year-old than in 40- and 60-year-old balsam fir forest in western Newfoundland (Hogan 1997). The objective of this study was to survey and compare the relative abundance or frequency of occurrence of woodpeckers among 40-, 60- and 80^{+}-year-old balsam fir forests. Comparisons of these results with those of woodpecker abundances in other northeastern North American forests, and in similar Scandinavian forest types, will provide better insight into woodpecker use of a managed balsam fir ecosystem.

2.2 METHODS

2.2.1 Study Sites

Thirty balsam fir study stands (> 300 ha each) were distributed throughout western insular Newfoundland (Figure 2-1). Ten of the sites in the Little Grand Lake area (48°36'N 57°52'W) were 80^{+}-year-old stands. This is the only significant area of 80^{+}-year-old balsam fir forest remaining in western Newfoundland. Ten sites each for 40- and 60-year-old stands were distributed throughout the Western Newfoundland Ecoregion (Meades and Moores 1989). All of the sites were of two closely-related common forest types: balsam fir/Dryopteris (slightly richer) and balsam fir/Hylocomium (slightly more moist) forest types (Meades and Moores 1989). The predominant tree species on all sites was balsam fir with a small

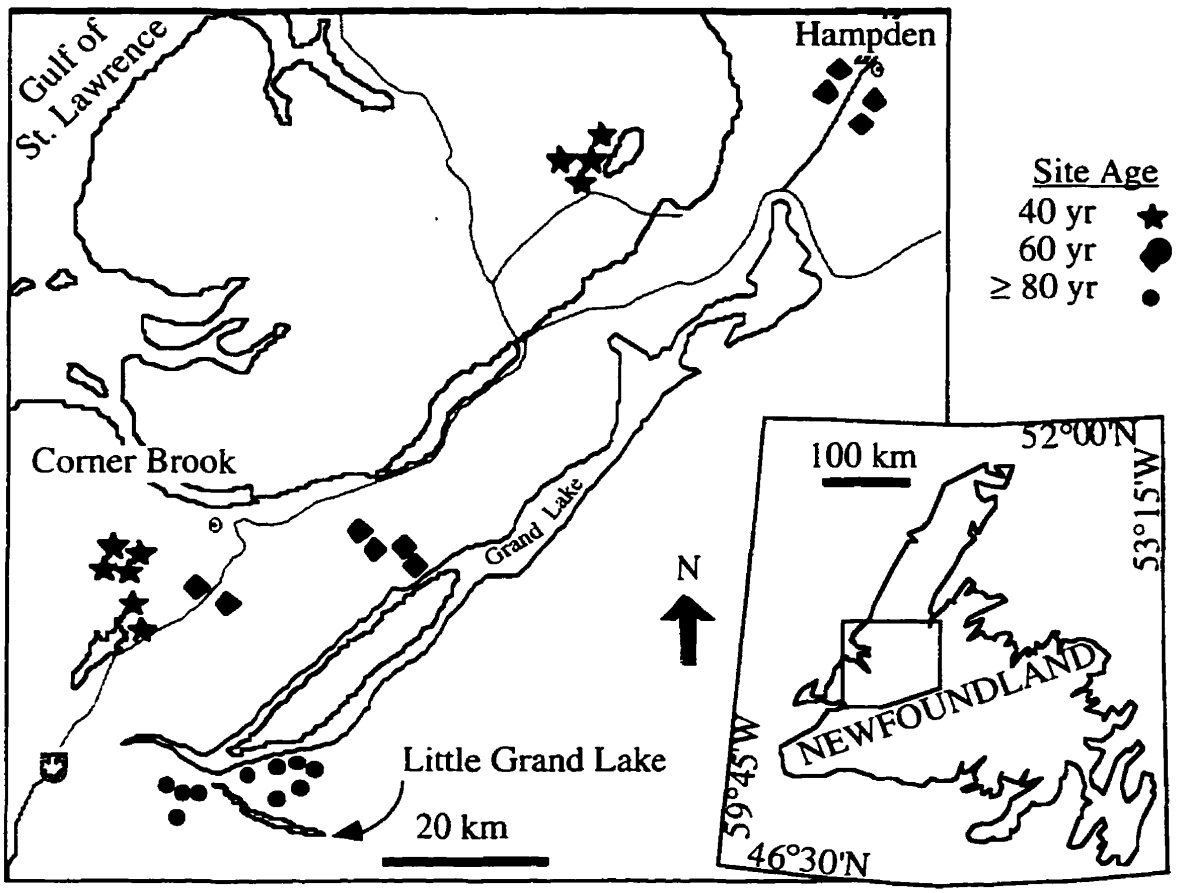


Figure 2-1. Distribution of study sites throughout western Newfoundland. Each stand contains five survey stations (except for one 60-year-old site that contains four), separated by 200 m.

component of black spruce, white spruce, eastern larch and white birch. Further stand structural characteristics are given in Chapter 3.

2.2.2 Survey Methods for Woodpeckers

The objective of doing the woodpecker survey was to use density as an indicator of habitat quality. It was assumed that where woodpecker density was highest, there must be some quality of that habitat that is beneficial to woodpecker populations (Anderson and Gutzwiller 1994).

Each of the 30 sites contained five survey points (except one 60-year-old site that contained only four). To avoid spatial overlap, points were located 200 m apart. To ensure that all birds heard drumming or calling were within the stand being measured, all points were ≥ 100 m from stand edges. The 30 sites were surveyed twice during a 6-week period from 27 May to 7 July during 1993 and 1994. Surveys commenced within 30 min after sunrise and were completed before 1030. Approximately two sites were visited each day by each of two observers.

It is difficult to accurately survey woodpeckers because of their secretive nature during incubation and typically large home ranges and territories. Woodpeckers may be missed using survey methods with only a few visits. However, in order to survey a representative proportion of balsam fir forests, the point-count method (Ryder 1986) was used. This method provided relative abundances rather than density which was sufficient for the objectives of this part of the study (Verner 1985; Welsh and Campbell 1991; Downes and Welsh 1993). The procedure was modified following the methods of Mosher et al. (1990) by the broadcasting of calls and drumming of black-backed, three-toed, downy and hairy woodpeckers (© 1994 Library of Natural Sounds, Cornell Laboratory of Ornithology, Ithaca, New York). 'Calls' included a mixture of drumming and vocalizations that are associated with territorial defense (Short 1982). This method was used to attract any woodpeckers that may otherwise remain undetected during a normal point-count (Johnson et al. 1981; Marion et al. 1981). Differences in detectability in different habitats were found by Majewski and Rolstad (1993):

black woodpeckers (*Dryocopus maritus*), were more difficult to find in 11–40-year-old than in > 70-year-old Norway spruce (*Picea abies*) and Scots pine (*Pinus silvestris*) forests.

Upon arrival at each site there was a 1-min rest period to allow both the observer and any disturbed birds to settle. However, woodpeckers did not appear to be disturbed by the presence of an observer (Amman and Baldwin 1960; pers. obs.). The first 2-min of the 10-min survey were spent listening and noting any birds. Species, sex and behavior (i.e., foraging, drumming, resting) of all birds heard or seen within 100-m of the points were recorded. Woodpecker 'calls' were then broadcast on a Realistic® CTR-76 2-track monaural system playing at 4.75 cm/sec at a 35 dB signal to noise ratio, amplified through an attached Realistic® Minimus®-0.6 amplified speaker with a frequency range of 150 ~ 15,000 Hz; SPL: 83 dB at 200 mV at 1 m, with a maximum output power of 2 W into a 4 ohm load and 100 ohms input impedance. This system was chosen primarily for compactness and durability for field transportation. Separate species calls were broadcast for 1-min intervals with 1-min of silence between each call, allowing the observer to record any response to broadcasted calls. During call broadcasting, observers continuously scanned the area for any silent woodpeckers. Even though it was not possible to test, all species appeared to have been equally responsive to call broadcasts (pers. obs.). While there are identifiable differences in the drumming and calling of the different species of woodpeckers (Short 1982; Ellison 1992; Kaufman 1993; pers. obs.), the observers relied on visual identification for confirmation of species and sex. Surveys were not conducted during periods of strong wind (> 11 km/hr), rain or fog, as this may have biased results by affecting observer performance or bird behaviour (Dawson 1981).

2.2.3 Data Analyses

There were no observable changes to stand structure on all of the sites for the duration of this study. There were no major areas of increased tree death or injury which could lead to increase in food supply or nest habitat, thus leading to a potential increase in woodpecker numbers. Therefore, for all sites, the highest recorded number of woodpecker observations

over the two seasons was used as an index of woodpecker abundance (similar to methods of Spytz 1993).

For comparative purposes with other published reports from northeastern North American forests, the 'Indice Ponctual D'Abondance' (IPA) ratio was calculated (Blondel et al. 1981). For an IPA, counts were translated into numbers of pairs if a drumming male, pair, occupied nest, or a family party were observed. Single birds seen or heard calling were scored as ½ pair (Blondel et al. 1981). The highest of the counts from the four visits to each point over the two years of the study were used as the IPA of that species for that point. An average IPA for a site equals the sum of point IPA totals divided by the number of points surveyed:

$$\text{IPA} = \frac{\sum(\text{point totals by species})}{\sum(\text{points surveyed})}$$

To provide an index of woodpecker abundance for statistical analyses, a frequency-of-occurrence index was used. Frequency-of-occurrence was calculated as the number of species occurrences divided by the number of point-counts per site:

$$\text{Frequency} = \frac{\sum(\text{species occurrences})}{\sum(\text{number points per site})}$$

For this ratio the maximum number of individuals observed was recorded, not as an estimated number of pairs. If similar activity was recorded at a point during successive surveys, then only one record was made for that species occurrence (e.g., if a drumming male was heard at the same point on two surveys, then that point was recorded as only one woodpecker present instead of two as for IPA).

For each survey point, the highest count of woodpecker sightings over the four visits was used to calculate frequency of occurrence for each site (i.e., total number of woodpeckers

sighted at each site / number of points on site = woodpecker abundance for that site = the detection ratio). Due to a high incidence of 0 values for woodpecker abundance, no data transformations were appropriate. Kruskal-Wallis tests (Sokal and Rohlf 1981; Abacus Concepts Inc. 1992), adjusted for tied values, were used to test for differences among age classes in the frequency of occurrence of woodpeckers per site.

2.2.4 Comparative Densities

Comparisons of relative abundance were possible between this study and Spytz (1993), who calculated IPA indices for black-backed, three-toed, downy and hairy woodpeckers in mixed-spruce forest of northeastern Ontario, and also for Sabine (1989) and Sabine and Makepeace (1990) who calculated IPA indices for downy and hairy woodpeckers in predominately hardwood forests of Prince Edward Island (PEI). Other indices included an index of relative abundance where the sum of observations from two visits to a site/year, tallied over several sites per habitat type, were recorded for black-backed, downy and hairy woodpeckers in conifer, hardwood, and mixed-growth stands in eastern Maine (Derleth et al. 1989). Home range and territory size of black-backed, three-toed, downy and hairy woodpeckers were estimated from several older publications and natural history reports of habitat use in conifer forests in the northeastern United States (Evans and Conner 1979). Territory densities (territories/10 ha) were calculated for several species of woodpeckers found on 24–98 ha plots of mixed Norway spruce-hardwood forests in Poland (Wesolowski and Tomialojc 1986). Line transects were used to calculate densities (birds/km^2) of woodpeckers in protected areas of scrub spruce and virgin spruce forest where 54% of the forest was ≥ 100-years-old, and in surrounding forest areas where only 10% of the forest was ≥ 100-years-old in southern Finland (Virkkala et al. 1994).

2.3 RESULTS

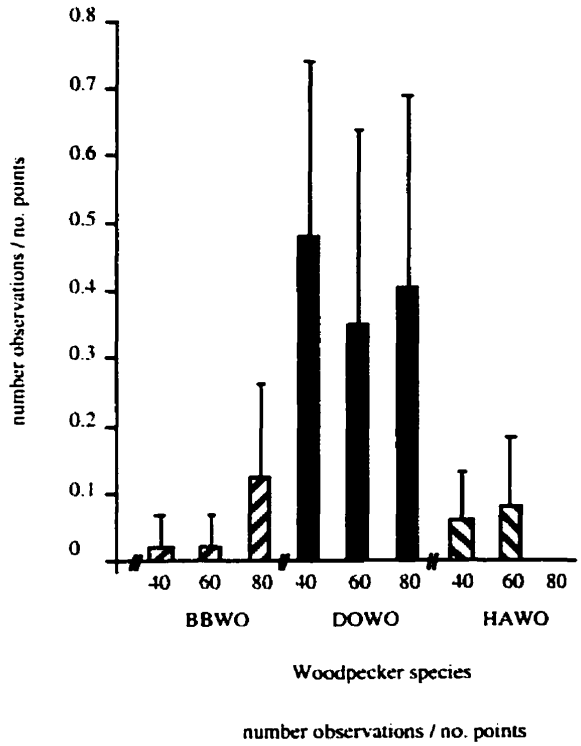
Black-backed woodpeckers were rare in all balsam fir age classes, with the frequency of occurrences of 0.02 per site (IPA = 0.01) for 40- and 60-year-old forest, and 0.12 sightings per site (IPA = 0.08) for 80^{+}-year-old forest (Table 2-1). These values are low in comparison to IPA values for more common birds found on the same survey points used for this study. For example, ruby-crowned kinglets (*Regulus calendula*) had an IPA value of 1.6 pairs/point, and white-throated sparrows (*Zonotrichia albicollis*) were 3.8 pairs/point in shrub-stage clearcuts in PEI (Sabine and Makepeace 1990). Eight independent sightings of black-backed woodpeckers and one sighting of a three-toed woodpecker were recorded. Black-backed woodpeckers were absent from the 1994 surveys. Hairy woodpeckers were also rare with seven independent sightings during both years of the survey, none of which was in the 80^{+}-year-old stands. Downy woodpeckers were more frequently observed with 53 sightings over the two survey seasons.

There were no significant differences in black-backed, downy and hairy woodpecker abundance among the different-aged forests (Kruskal-Wallis $P = 0.15, 0.79, 0.16$ respectively). However, there was a trend for black-backed woodpeckers to be found more commonly in the 80^{+}-year-old stands than in the 40- and 60-year-old stands, while downy woodpeckers were evenly distributed among age classes (Figure 2-2). All abundance indices showed the same general trends for each woodpecker species (Figure 2-2, Table 2-1).

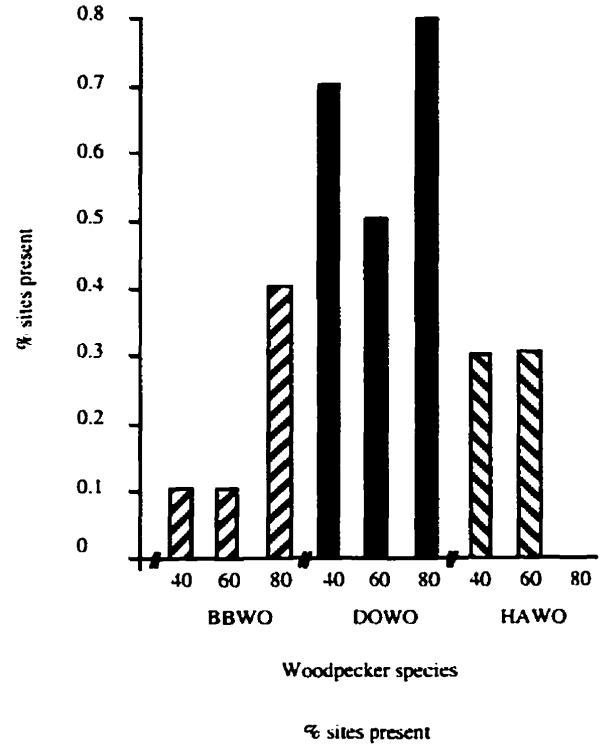
Table 2-1. Breeding season abundance statistics for black-backed (BBWO), downy (DOWO) and hairy (HAWO) woodpeckers in different-aged balsam fir forests in western Newfoundland, 1993–1994. The number of individual sightings/number of points per site (n / no. points) (± SD), IPA (see text for calculation) (± SD), and the percentage of sites where species detected (Detection (%)). All differences among age classes were non-significant (Kruskal-Wallis, $P \gg 0.10$).

	n / no. points			IPA			Detection (%)		
Species	40	60	80	40	60	80	40	60	80
BBWO	0.02	0.02	0.12	0.01	0.01	0.08	0.10	0.10	0.40
	(0.06)	(0.06)	(0.19)	(0.07)	(0.07)	(0.23)			
DOWO	0.44	0.35	0.40	0.27	0.17	0.20	0.70	0.50	0.80
	(0.36)	(0.40)	(0.27)	(0.35)	(0.28)	(0.30)			
HAWO	0.06	0.08	0.00	0.04	0.05	0.00	0.30	0.30	0.00
	(0.10)	(0.14)	(0.00)	(0.17)	(0.21)	(0.00)			

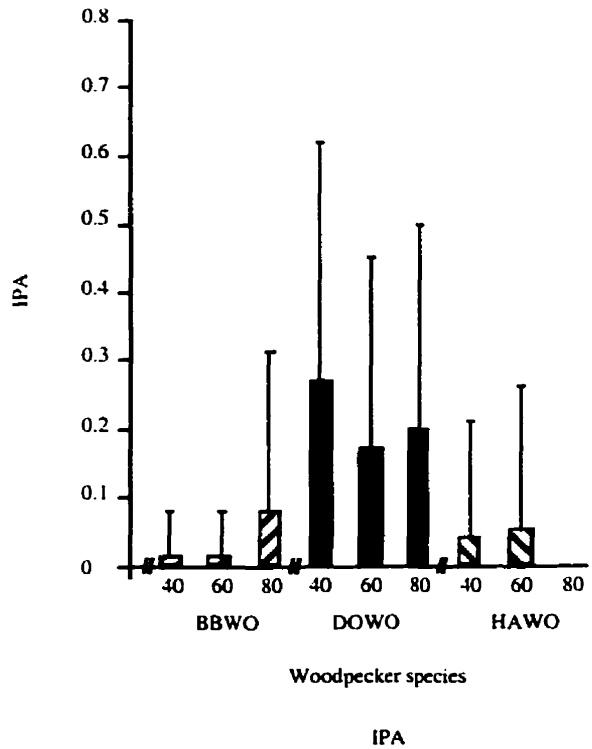
Figure 2-2. The number of woodpeckers observed per point, percentage of sites observed and IPA indices (see text for calculation) for 10 sites each of 40-, 60- and 80+-year-old balsam fir forest, western Newfoundland, 1993–1994. Error bars represent ± 1 standard deviation.



number observations / no. points



% sites present



IPA

2.3.1 Comparative Densities

Comparative IPA values were uncommon for black-backed and three-toed woodpeckers. However, abundance appears to be higher in balsam fir forests (IPA = 0.02–0.12) than in the mixed forest of northeastern Ontario (IPA = 0.01) (Table 2-1, Table 2-2.). Spytz (1993) calculated an IPA value for grouped forest ages and stated that the few observations of black-backed and three-toed woodpeckers were limited to uncut ≥ 70-year-old-forest (Table 2-2). Comparisons with other abundance indices from published sources showed that three-toed woodpeckers in mixed Norway spruce-hardwood forests of Poland were too rare for determination of abundance or density (Wesolowski and Tomialojc 1986). Three-toed woodpeckers were 'scarce' in southern Finland with densities ranging from 0.03 pairs/km^2 in the younger forest, to 0.36 pairs/km^2 in the protected conifer forest > 100-years-old (Virkkala et al. 1994). Evans and Conner (1979) estimated a surprisingly high density of black-backed and three-toed woodpecker pairs at 3.3 pairs/km^2, based on their estimated territory size of 30 ha in the northeastern United States. There was only one published record of a black-backed woodpecker found in a recent conifer clearcut in a four-year survey (Derleth et al. 1989; Table 2-3).

Comparative IPA values indicate that downy woodpeckers are relatively more abundant in balsam fir forests of Newfoundland (IPA = 0.20–0.27) than in both mixed spruce-fir-aspen-birch stands in northeastern Ontario (IPA = 0.03) and most tolerant hardwood forest types of PEI (IPA ≤ 0.20), excluding thinned 50–100-year-old tolerant hardwood stands (IPA = 0.43) (Tables 2.1, 2.2). Hairy woodpeckers appear to be less abundant in balsam fir forests than in the mixed forests of northeastern Ontario or in the tolerant hardwood stands of PEI (Table 2-2). An estimate of a maximum number of downy woodpecker pairs was 25 pairs/km^2 and for hairy woodpeckers 12.5 pairs/km^2 in various forest types of the northeastern USA (Evans and Conner 1979). Downy woodpeckers were found primarily in conifer and hardwood stands in eastern Maine, whereas hairy woodpeckers were found

throughout conifer, hardwood, and mixed-wood stands, but were found more often in recent conifer clearcuts or mixed growth stands.

Table 2-2. IPA counts for woodpeckers in northeastern forests. (See text for calculation of IPA index).

Forest Type	Location	DOWO	HAWO	BBWO	TTWO	Source
Mixedwood[1]	NE Ont.	0.03	0.07	0.01	0.01	Spytz 1993
White spruce						
clearcut, slash left	PEI		0.13			Sabine and Makepeace 1990
clearcut, shrub stage	PEI	0.06				
mature, unthinned	PEI	0.06				
overmature, < 50% mortality	PEI		0.07			
Black spruce						
pre-commercial thin	PEI		0.07			
Tolerant hardwood						
30–50 yr	PEI	0.10	0.10			Sabine 1989
50–100 yr	PEI	0.17	0.08			
> 100 yr	PEI	0.15	0.10			
30–50 yr thinned	PEI	0.07	0.13			Sabine and Makepeace 1990
50–100 yr thinned	PEI	0.43	0.07			
30–50 yr old thin	PEI	0.07	0.07			
50–100 yr unthinned	PEI	0.20	0.13			
100+ unthinned	PEI	0.21	0.07			

[1] Black spruce, balsam fir, trembling aspen (*Populus tremuloides*), white birch.

Table 2-3. Woodpecker abundance index from Derleth et al. (1989). Ten plots for each treatment were surveyed twice in one year. The two counts were then summed to provide an index of woodpecker abundance. Conifer control = 15–20 m high, ~50 years old, spruce, balsam fir and white pine. Treatment = 0–1 year old clearcut, eastern Maine.

	Conifer		Hardwood		Mixed Growth	
Species	Control	Treatment	Control	Treatment	Control	Treatment
DOWO	0	1	0	1		
HAWO	1	4	1	0	2	2
BBWO	0	1				

2.4 DISCUSSION

2.4.1 Distribution

Determining population density of rare or scarce endemic woodpecker populations has proven to be a difficult task for many researchers trying to calculate an index of woodpecker abundance (Amman and Baldwin 1960; Evans and Conner 1979; Wesolowski and Tomialojc 1986; Virkkala et al. 1994; Hutto 1995; M. Cadman, Canadian Wildlife Service, pers. comm.). It has proven to be equally challenging for this study as well.

While there was no significant difference in abundance of black-backed woodpeckers among age classes, there was a trend for them to occur more frequently in the 80^{+}-year-old-stands than in the 40- and 60-year-old stands, a similar trend that has been recognized by many other researchers, even though data and statistical differences are lacking (e.g., Evans and Conner 1979; Helle and Järvinen 1986; Wesolowski and Tomialojc 1986; Virkkala et al. 1994). The absence of black-backed woodpeckers in the 1994 surveys concurs with the observation from a long-term study which indicated that sedentary species had the greatest yearly variation in density (Virkkala 1989). It was also found that bird populations at low density tended to fluctuate more in sub-optimal habitat than in optimal habitats where densities are higher (Virkkala 1989). The number of spruce forest specialists fluctuated more in managed (thinned, harvest rotation forests), than in > 200-year-old natural forests (Virkkala 1989; Virkkala 1991*a*). However, when assessing habitat use of a specialized species at low density, an absence may only be temporary from sites that are necessary for long-term existence (Haila 1994). However, two seasons of survey data from this study and

another two seasons from Hogan (1997) have consistently shown that black-backed woodpeckers rarely occurred in balsam fir stands younger than 80 years old.

All of the published literature with comparative woodpecker densities showed that black-backed and three-toed woodpeckers were scarce, but were relatively more abundant in the oldest conifer forest types surveyed, similar to the trend of black-backed woodpecker abundance found in the present study. Hutto (1995) provides further comments on this type of distribution with the conclusion that the relatively low numbers of black-backed woodpeckers in unburned forests in Montana may be sink populations that are maintained by birds that emigrate from burns when conditions become less suitable 5 to 6 years after a fire. This may also occur in western Newfoundland where insect defoliation replaces fire as the primary method of stand regeneration (Chapter 1). Endemic populations of black-backed and three-toed woodpeckers may react to the resulting increase in wood-boring insect food abundance in recently defoliated stands. Dead trees provide a suitable substrate for wood-boring insects up to five years after defoliation (Warren 1989), while weakened trees may persist several years longer. Black-backed woodpecker populations in Montana may be maintained over time by either refuges of low numbers in unburned forests, or a patchwork of recently burned areas (Hutto 1995). Within the last century in Newfoundland, balsam fir forests have experienced at least eight insect defoliations of epidemic proportions, affecting hundreds of thousands of hectares. Yearly endemic, localized insect defoliation events that occur throughout the balsam fir forest maintain a mosaic of 100s of hectares in various stages of morbidity (A. Carroll, pers. comm., Can. For. Serv., Nfld., 19 Aug. 1996). The endemic defoliation events could support small black-backed and three-toed woodpecker populations between severe outbreaks, after which large areas of dead and dying trees provide suitable substrate for wood-boring insect larvae. Black-backed woodpeckers may have been scarce during 1993 and absent from the surveys during 1994, as there has not been a defoliation outbreak for more than five years prior to this study. It would be interesting to continue long-term surveys during and after epidemic defoliation events to determine if there is a numerical response of woodpeckers to an increase in food abundance.

The present study and studies published from other northeastern forest types show that downy and hairy woodpeckers are found in a variety of forest types containing hardwood stems. The scarcity of hairy woodpeckers in this study may be due more to their reliance on a higher density of hardwood stems as a substrate for finding food than can be found in most of the balsam fir stands. Balsam fir forest is perhaps marginal habitat for hairy woodpeckers. Both downy and hairy woodpeckers will probably be unaffected by harvest rotations in balsam fir forest as long as there is some standing hardwood component left as residual after harvest.

2.4.2 Methodological Critique

The IPA method assumed that every bird seen or heard drumming constitutes a pair. This may not apply to woodpeckers of this study as both males and females drum, often being associated for the purpose of communication between mated pairs or for territorial defense (Ellison 1992). However, drumming does not necessarily mean that woodpeckers are paired. Drumming can be heard throughout the year at times when woodpeckers are not mated (pers. obs.), and by unpaired individuals during the breeding season (Short 1982). These assumptions should be considered when applying IPA indices to woodpeckers. However, possible insufficiencies in the data due to this potential source of error do not affect the between-site comparisons of relative abundance.

Unlimited distance point-counts are not an effective survey method for counting woodpeckers occurring at low abundance. Because time is limited at points and area coverage is low relative to woodpecker behaviour patterns and territory sizes, limiting counts to certain pre-determined points resulted in low detections. This led to statistically unsuitable data for scarce species. However, the use of broadcast calls did prove to be a useful tool for locating inconspicuous woodpeckers; otherwise the detection rate may have been significantly lower.

2.4.3 Recommendations for Improving Survey Methods

For future research where abundance of woodpeckers must be determined, I suggest a mixture of transects and point counts where the observer walks along a transect with periodic stops at promising locations (e.g., signs of recent feeding, or in groups of trees in various stages of morbidity) and broadcast woodpecker calls. This method has proved useful for locating red-breasted sapsuckers (*Sphyrapicus ruber*), hairy woodpeckers and northern flickers in Douglas-fir/western hemlock forests and forest edges on northern Vancouver Island, British Columbia (pers. obs.). Lengths of transects and area coverages should be proportional to stand size or amount of area among treatments. A more useful method to determine abundance where density can be calculated could be the use of fixed-width strip searches. Forest stands would be transected, and all woodpeckers heard within a certain distance from the observer would be identified. One-half of the strip width is determined by the maximum distance that a woodpecker species can be heard drumming. Downy woodpeckers are probably the quietest of all four of the woodpeckers, while the loudest is drumming of hairy woodpeckers, or three-toed or black-backed woodpeckers feeding young at a nest. If a census of all woodpeckers is desired, then the maximum distance that a downy can be heard should be used as a guide. Amman and Baldwin (1960) had some success with this method in spruce-fir forest of Colorado, and suggested a strip width of 40 m (20 m either side) as suitable for surveying endemic woodpecker populations at very low abundance. However, they also found it necessary to add population estimates of three different woodpecker species to gain a large enough sample without zero values to analyze for differences between survey methods. Due to large home-ranges and infrequent encounters with woodpeckers, such surveys must be extensive. Perhaps the number of sites sampled would be small, but they should cover large areas in three different age-classes of forest. During woodpecker surveys, observers should be looking for signs of recent woodpecker activity rather than just the bird species themselves. Areas of recent or old feeding and nesting activity are good locations for broadcasting calls to draw in silent woodpeckers from perches. Stopping and listening quietly for the faint tapping of an excavating or feeding woodpecker

will often facilitate location of woodpeckers that may be missed if the observer is continuously walking transects. However, the degree of intensity required for these types of surveys is best illustrated by Verner (1986) who concluded that because of low abundance of pileated woodpeckers (*Dryocopus pileatus*), total costs would exceed $ 1,000,000 US per year to detect a 10% change in numbers between years (with 95% confidence) on random sample points. The same effort may have to be involved for an intensive survey of black-backed or hairy woodpeckers in Newfoundland. This should not discourage any further research into the distribution and abundance of woodpeckers in balsam fir forests. Questions of distribution of scarce species like woodpeckers require long-term studies on a large number of large study plots.

3. NEST CHARACTERISTICS AND NEST-HABITAT SUITABILITY FOR WOODPECKERS IN 60-YEAR HARVEST ROTATION BALSAM FIR FORESTS IN WESTERN NEWFOUNDLAND

3.1 INTRODUCTION

The relationship between cavity-nests and surrounding forest structure has been described in several studies throughout North America, but most of the studies have been conducted in northwestern forests of the United States (Table 3-1). Studies in eastern North America have been conducted primarily in hardwood forests, except for Spytz (1993) in black spruce – balsam fir – trembling aspen – white birch forests in northeastern Ontario (Table 3-1). European research has been conducted either in hardwood forests for species not found in Newfoundland (e.g., white-backed woodpeckers (*Picoides leucotos*) Bernoni (1994)), or for three-toed woodpeckers in Scandinavian spruce-dominated forests (Hågvar et al. 1990; Angelstam and Mikusinski 1994; Table 3-1).

Much past research has considered the abundance of naturally occurring nest-hole-sites or suitable trees for excavation as a limiting factor to primary cavity-nesting populations (see references in Beebe 1974; Zarnowitz and Manuwal 1985; Welsh and Capen 1992; Ohmann et al. 1994). However, nest substrate may not be the only limiting factor to woodpecker populations. Other site variables such as stem density and number of dead stems as suitable food substrates may also play an important role in nest-site selection. However, there have been no published studies of these factors in areas surrounding nest-sites.

Tree diameter and age were positively correlated with white-backed woodpecker nests in mixed to pure beech-woods forests in central Italy (Bernoni 1994). It was also found that cavity abundance was not related to topographic position, site index, or stand characteristics (Carey 1983*a*). However, forest damage caused by random events such as wind storms and fire appeared to play the major role in determining the placement of a nest (nest- tree)

location (Carey 1983*a*). Considering the type and variety of ecological patterns described in these studies, it is impossible to predict the habitat characteristics of the resident woodpecker species in balsam fir forests of insular Newfoundland without investigating that particular forest type.

Table 3-1. Studies of relationships between cavity-nest and surrounding forest types conducted throughout North America and in Scandinavian three-toed woodpecker habitat.

Location	Forest type[a]	Source
coastal Oregon	Douglas-fir	Mannan et al. 1980
Oregon	mixed conifer, lodgepole pine	Goggans et al. 1988
NE Oregon	mixed conifer	Bull et al. 1992
Montana	western larch, Douglas-fir	McClelland and Frissell 1975
Arizona	mixed conifer	Li and Martin 1991
Arizona	conifer dominated, but *Populus* spp. used for nest-site	Conway and Martin 1993
West Virginia	hardwood	Carey 1983b
Virginia	hardwood	Conner et al. 1975
New York	riparian, second-growth hardwood	Swallow et al. 1986
New York	second-growth beech, birch, maple	Welsh and Capen 1992
NE Ontario	mixed black spruce, balsam fir, trembling aspen, white birch,	Spytz 1993
New Brunswick	upland hardwood slopes and ridges	Parker and Kimball, unpubl. data
Italy	beech	Bernoni 1994
Scandinavia	spruce dominated	Hågvar et al. 1990
Scandinavia	spruce dominated	Angelstam and Mikusinski 1994

[a] western larch (*Larix occidentalis*), Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), beech (*Fagus grandifolia*), birch (*Betula* spp.), maple (*Acer* spp.), black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), white birch (*Betula papyrifera*).

Few studies have quantified the abundance of cavities in forests (see citations in Carey 1983a). Woodpeckers usually excavate a new nest-hole each year and may excavate several holes before choosing one as a nest-site. The first objective of my study was to gain insight into historical use by woodpeckers of different-aged balsam fir forests by determining existing cavity densities. The second objective was to determine if there will be suitable

woodpecker nesting habitat under a 60-year even-aged balsam fir harvest rotation by relating habitat characteristics recorded at nest-sites to the same habitat variables measured throughout 40-, 60- and 80+-year-old forests.

3.2 METHODS

There were 10 sites each in 40-, 60- and 80+-year-old balsam fir forests. During 1993, information was collected on all pre-existing cavities that were found within a 10 x 800 m transect through each of the 30 study sites. The species that constructed these cavities, and whether they were nest-sites, roosting-sites or not used was unknown. These data were used as an indication of historical site use by woodpeckers, availability of cavities, cavity height, aspect of opening (corrected to true north) and tree species selected. To include only recently constructed cavities, dead, very soft and deteriorated trees were excluded from this count.

Active nest-cavity searches were conducted in the vicinity of the study sites mentioned above. Daily nest searches began on 24 June 1994 and continued opportunistically throughout the season until no nesting activity was observed (last active downy woodpecker nest was located on 24 July). Nest searching began late in the season due to concurrent bird census work from 07 June – 07 July and was assumed to cover a representative sample of woodpecker nesting habitat in western Newfoundland balsam fir forests. Searches began 30 min before dawn and continued throughout the day, but by 1200 hr observed woodpecker activity had usually ceased. Almost all nests were located by walking along logging roads or forest edges, listening and looking for adult woodpeckers or nestlings calling (similar to methods of Goggans et al. (1988)). A cavity was considered a nest-site if chicks were heard calling or adults were seen carrying food into the cavity.

Habitat features were sampled at 14 woodpecker nests: four black-backed (BBWO), four downy (DOWO), five hairy (HAWO) and one three-toed woodpecker (excluded from analyses). Characteristics of the nest-cavities, nest-trees and forest immediately around nests were measured at each site. Nest-cavity measurements included nest-height and aspect of

opening (to the nearest degree, corrected to true north). Nest-tree and cavity-tree measurements included diameter at breast height (dbh), species, height (Suunto, nearest 0.25m), number of cavities and vigor classification (1= healthy tree, no signs of weakness, 2 = moderate, signs of weakness such as large dead branches, 3 = poor, only one or a few living branches, 4 = dead; (Hågvar et al. 1990), but later classified as either alive (1) or dead (4) for ease of comparison and presentation).

The cavity data collected in this study, supplemented with nest-tree measurements throughout Newfoundland were compared to cavity data from other regions. Literature describing the range of woodpecker cavity-nest characteristic measurements is extensive (see Short 1982). Comparative cavity-nest site measurements were taken from literature for research conducted east of the Rocky Mountains or in similar forest types where three-toed woodpeckers exist in Scandinavia.

Forest structure within a 0.04 ha (11.3 m) radius plot centered on the nest-tree was described to represent the micro-site habitat scale of woodpecker nest-sites. In order to determine if habitat differences were related to cavity orientation, the plots were divided into four quadrants, where quadrant one was centered on the direction of the cavity opening (Figure 3-1). Within each quadrant, dbh was measured for all trees (≥ 1m tall, ≥ 5.0 cm dbh) and saplings (≥ 1m tall, ≤ 5.0 cm dbh) were counted. Crown closure was estimated at each point where quadrant lines intersected the plot boundary (Figure 3-1). To determine if habitat structure was related to distance from the cavity tree, point sample measurements were taken at 40 and 80 m intervals from the nest-tree along the extended quadrant boundary. These points were considered to be representative of an area within a 100 m radius (meso-habitat scale). Previous research in southeastern pine forest has suggested that habitat within 100 m of the nest is different from habitat at 200 m (Hovis and Labisky 1985; Kelly et al. 1993). Point sample measurements for stem density and average dbh were taken using a 2.29 m^2/ha factor prism (converted from an Imperial BAF = 10 factor prism). Crown closure, height and age data were not collected at these points.

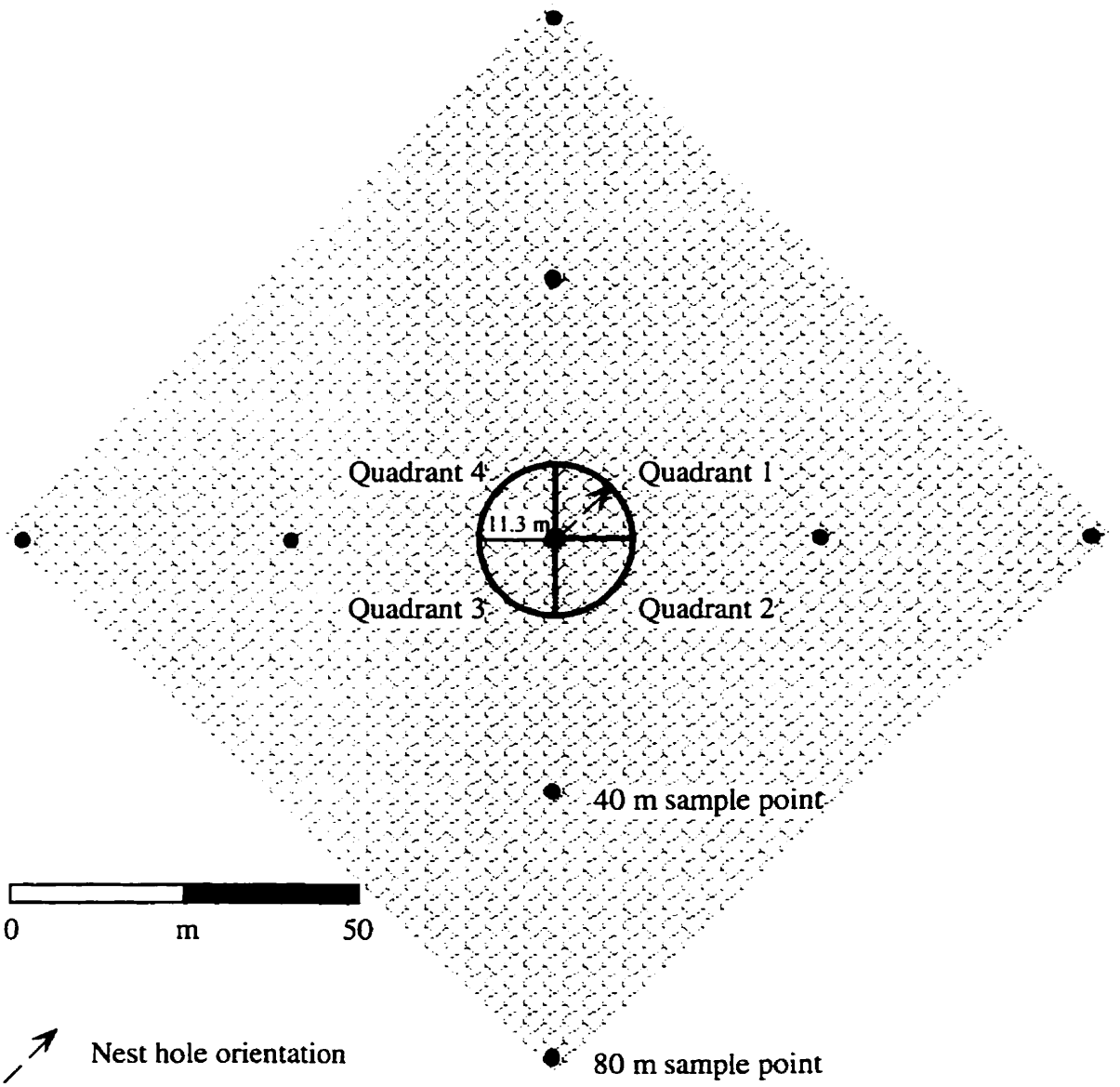


Figure 3-1. Micro- (Nest) and meso- (Tran.) scale habitat sampling design used at 14 woodpecker cavity sites in western Newfoundland. Quadrant 1 was centered on the cavity opening (Source: Kelly et al. 1993).

To determine if habitat structure at the nest was different from the surrounding forest (macro-habitat scale), species composition, vigor (1 = live, 4 = dead), dbh (2 cm classes), height, tree density, and crown closure were measured in four 6-ha blocks surrounding each nest-site (Figure 3-2). Point samples were taken at a sampling intensity of 2.2 points/ha, closely following the recommendations of Husch et al. (1982: 253), adjusted for a northern balsam fir forest. At each point measurements were made of the following variables: tree species, vigor (as above), dbh (calipers at 2 cm classes), visually estimated crown closure, height and age at breast height of one to three dominant or co-dominant sub-sample trees. Live and dead stems were placed in categories of small (10–18 cm), medium (20–28 cm) or large (≥ 30 cm) dbh classes because they include the 'optimum' nest diameter classes for the four woodpecker species investigated in this study (Evans and Conner 1979; Spytz 1993). Unfortunately, I was unable to determine how much of the area sampled as 'nest area habitat' was actually used by each woodpecker family group. It has been observed that nest-trees for many woodpecker species are often at the periphery of a home range (Winkler et al. 1995), so while these measurements are perhaps not as specific as they should be for identification of nest-site structure, they do provide large-scale, measurable components of woodpecker nesting habitat.

3.2.1 Data Analyses

The density of existing cavity trees on each of the 30 study sites was grouped by site age. A partial (Type 3) sum of squares one-way analysis of variance was calculated using site age as a predictor of the number of cavities found per hectare (General linear models procedure, Data Description 1995). The 126 cavity hole orientations were grouped into categories of 15° and the Chi-square goodness of fit was used to test for randomness of orientation of opening. The 13 cavity-nest orientations were tested for randomness using

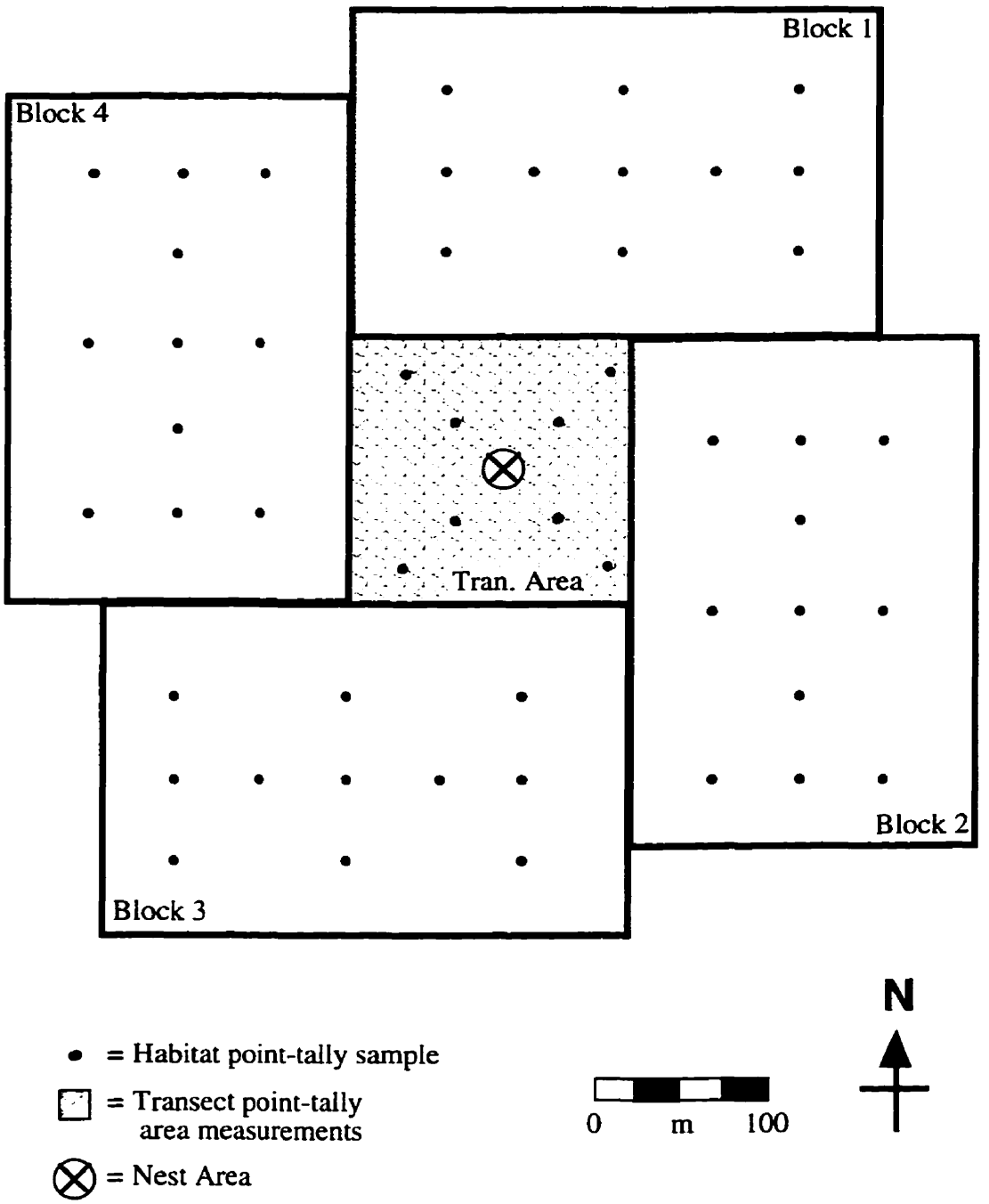


Figure 3-2. Block (macro-scale) habitat sampling design used at 14 woodpecker cavity-nest-sites in western Newfoundland. Orientation of nest area sampling varied depending on orientation of nest opening.

Watson's one-sample U^2 goodness of fit test (Zar 1984). The null hypothesis was that cavities exhibit random orientation. Mean angle (θ) and mean vector lengths (r) were presented for all cavities. Mean vector length is a unitless measure of the concentration of the cavity orientations; it can range from 0 at low concentration to 1 at high concentration.

Comparisons of nest-tree characteristics among woodpecker species were made with a partial (Type 3) sum of squares one-way analysis of variance with unequal sample sizes (Green 1979; General linear models procedure, Data Description 1995). The small sample size of 13 nests (BBWO n = 4; DOWO n = 4; HAWO n = 5) precluded any conclusive interspecific statistical comparisons of cavity-nest characteristics. Given a significant result from an analysis of variance model ($P \leq 0.05$), further analytical comparisons were made using the Least Significant Difference multiple comparison method (Sokal and Rohlf 1981; Post-hoc comparisons procedure, Data Description 1995). Due to low sample size and poor model fit, crown closure and tree height among quadrants at nest-sites were compared with a Kruskal-Wallis (H) test corrected for ties (Sokal and Rohlf 1981).

All general linear model residuals were examined for constant variance using plots of externally Studentized residuals versus predicted values plots. Distributions of the residuals were examined for normality through normal (n-scores) probability plots (Data Description 1995).

3.3 RESULTS

There were differences in the number of cavities per hectare among age classes ($F_{2,77}$ = 5.1, $P \leq 0.02$) with more cavities in 80$^+$- ($\bar{x}$ = 6.1 ± 5.1 stems/ha, n = 49 trees) than in 40- ($\bar{x}$ = 1.9 ± 1.8 stems/ha, n = 15) and 60-year-old ($\bar{x}$ = 2.3 ± 1.9 stems/ha, n = 18) balsam fir stands (LSD: Diff. ≥ 3.9 ± 1.5 cm (SE), $P \leq 0.02$). There was no difference in cavity-tree density between 40- and 60-year-old stands (LSD: Diff. = 0.38 ± 1.4 cm (SE), $P = 0.80$; Figure 3-3). Cavity-trees were 80% balsam fir (71 trees), 15% white birch (10 trees), and 1% black spruce (1 tree), similar to the overall species composition found on the study sites.

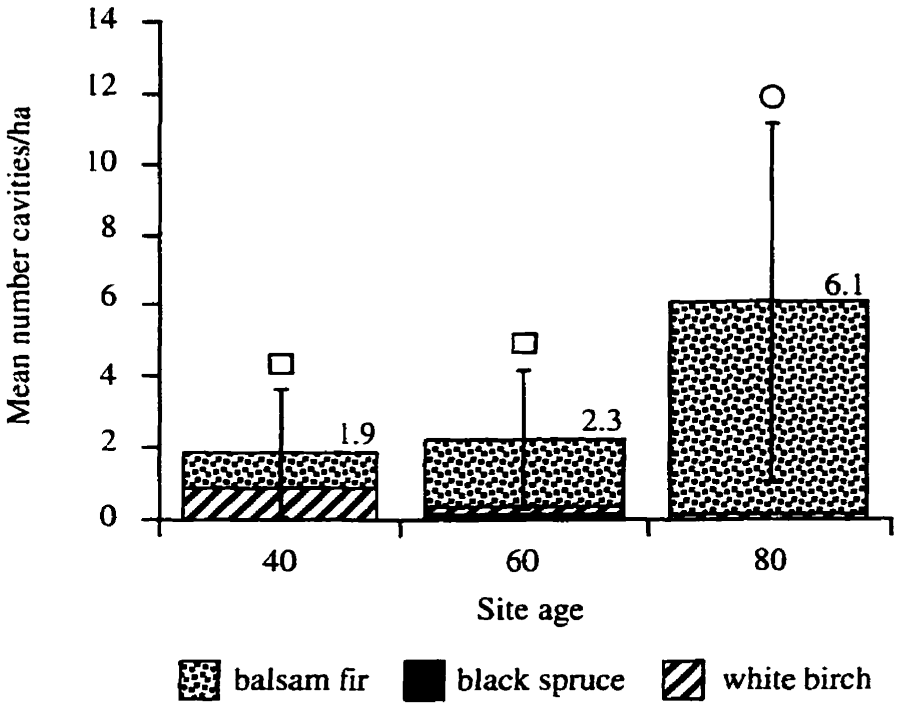


Figure 3-3. Number of cavities per hectare found on thirty 10 x 800 m transects through balsam fir forest in 40- (15 cavities), 60- (18 cavities), and 80*- (49 cavities) year-old age classes (10 transects each) in western Newfoundland. Error bars represent ± 1 SD for number of cavities/ha for all tree species combined. Bars topped by different symbols represent significant differences among age classes (ANOVA; $P \leq 0.05$; LSD; $P \leq 0.05$).

The mean cavity-tree diameter was within the upper 25% of the dbh distribution of the balsam fir stands for all stems ≥ 10 cm dbh. There were differences in the mean dbh of balsam fir cavity-trees among age classes ($F_{2,67} = 5.2$, $P = 0.01$). Balsam fir cavity-trees in 80-year-old stands have a larger mean dbh ($\bar{x} = 23.9 \pm 5.5$ cm, $n = 47$) than in 40- ($\bar{x} = 19.3 \pm 2.8$ cm, $n = 8$; LSD: Diff. = 4.5 ± 1.9 (SE), $P = 0.02$) and 60-year-old stands ($\bar{x} = 20.0 \pm 4.1$ cm, $n = 15$; LSD: Diff. = 3.9 ± 1.5 cm (SE), $P = 0.01$). There was no difference in balsam fir cavity-tree mean dbh between 40- and 60-year-old stands (LSD: Diff. = 0.63 ± 2.2 cm (SE), $P = 0.78$; Table 3-2). There were differences in balsam fir cavity-tree height among age classes ($F_{2,68} = 3.26$, $P = 0.04$), being taller in 80*- ($\bar{x} = 5.9 \pm 2.31$ m, $n = 47$) than in 40- ($\bar{x}$

= 4.2 ± 1.1 m, n = 8; LSD: Diff. = 1.68 ± 0.96 (SE); P = 0.05) and 60-year-old stands ($\bar{x}$ = 4.69 ± 2.08 m, n = 14; LSD: Diff. = 1.25 ± 0.64 (SE), P = 0.05; Table 3-2).

Table 3-2. Mean and range of cavity-tree characteristics for 71 balsam fir trees with 113 cavities found on 30 10 x 800 m transects, on 10 sites each of 40-, 60- and 80+-year-old balsam fir stands (no. cavity trees found in parentheses) in western Newfoundland. Variables that are followed by a different letter are significantly different among forest age classes (ANOVA: $P \leq 0.05$, LSD: $P \leq 0.05$).

Age class	40 (8)		60 (15)		80 (48)		All ages (71)	
Mean cavity-tree variables	$\bar{x}$	(SD)	$\bar{x}$	(SD)	$\bar{x}$	(SD)	$\bar{x}$	(SD)
dbh (cm)	19.4[a]	(2.3) [16–24]	20.0[a]	(4.1) [12–29]	23.9[b]	(5.5) [15–39]	22.5	(5.5) [12–39]
Cavity height (m)	3.7	(1.0) [2.0–5.0]	3.7	(1.6) [1.9–6.5]	3.9	(1.5) [1.5–9.0]	3.8	(1.5) [1.5–9.0]
Tree height (m)	4.2[a]	(1.1) [2.5–5.5]	4.6[a]	(2.1) [2.0–10.0]	5.9[b]	(2.3) [2.5–14.0]	5.4	(2.2) [2.0-14.0]
Cavity/tree height	0.87[a]	(0.07) [0.73–0.94]	0.83[a]	(0.14) [0.5–0.96]	0.69[b]	(0.19) [0.27–0.95]	0.74	(0.18) [0.27–0.95]

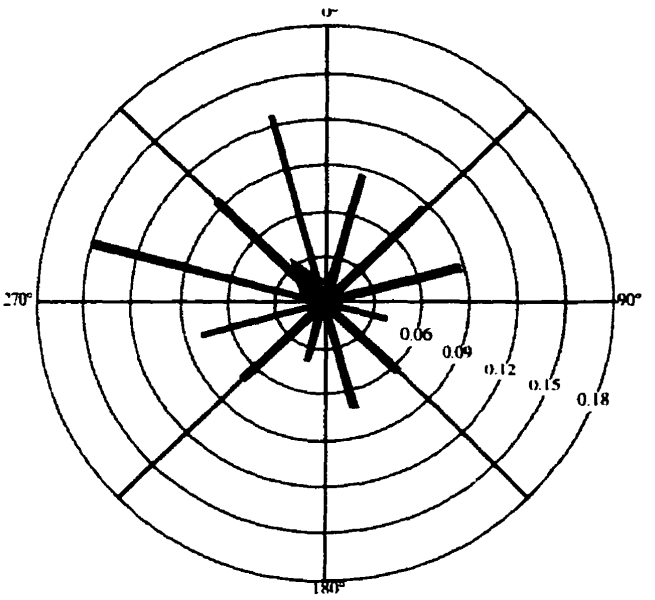
The 126 cavity openings in 82 trees were randomly oriented (χ^2 = 14.26, df = 125, P = 1.00; Figure 3-4a). The orientation of the 13 nest-cavity openings was not randomly distributed and tended to open to the east-southeast, or roughly perpendicular to the west-southwest prevailing wind direction (115° ± 73°, r = 0.45, U^2 = 2.24, $P \leq 0.01$ for all nests combined; 120° ± 18°, r = 0.95, U^2 = 5.99, $P \leq 0.01$, n = 4 for black-backed woodpeckers;

118° ± 43°, $r = 0.75$, $U^2 = 5.63$, $P \leq 0.01$, $n = 5$ for hairy woodpeckers). However, downy woodpecker nests were more random in orientation and opened at 281° ± 78° ($r = 0.40$, $U^2 = 3.88$, $P \leq 0.01$, $n = 4$; Figure 3-4b). The nest-cavity trees were composed of 14% balsam fir, 57% white birch and 29% of either white or black spruce and eastern larch (*Larix laricina*). Black-backed woodpecker nests were found in two dead eastern larch, one dead white spruce and one dead balsam fir. Downy woodpecker nests were found in two dead white birch and two dead balsam fir, hairy woodpecker nests were all in dead white birch, and the one three-toed woodpecker nest was in a dead black spruce. Most nest-trees had broken tops. The mean dbh of all nest-cavity trees was 31.9 ± 8.8. cm (20.1–47.6 cm, n = 14; Table 3-3). These nest-tree diameters were within the upper 5% of stand dbh for stems ≥ 10 cm dbh.

There were no differences in the density of live or dead stems ≥ 10 cm dbh or mean dbh among the four 100 m^2 quadrants for black-backed, downy or hairy woodpecker (Quad., Table 3-4). There were no differences in the height of combined live and dead trees among quadrants for black-backed ($F_{3, 13} = 0.715$. $P = 0.56$), downy ($F_{3, 10} = 2.904$, $P = 0.09$) or hairy ($F_{3, 37} = 0.040$, $P = 0.99$) woodpeckers. There were no differences in crown closure among quadrants for black-backed ($H = 3.792$, $n = 12$, $P = 0.28$), downy ($H = 3.655$, $n = 16$, $P = 0.30$) and hairy ($H = 0.776$, $n = 20$, $P = 0.86$) woodpeckers. Therefore, for further analyses, all quadrants at each nest were pooled for measures of nest-habitat characteristics immediately surrounding nest-sites (the area referred to as "Nest").

Figure 3-4 a) A circular relative frequency histogram of cavity orientation from 126 cavities in 82 trees in 40-, 60-, and 80+-year-old balsam fir stands; b) Nest-cavity orientation for 13 woodpecker nests in western Newfoundland ($\theta = 115° \pm 73$; four black-backed ($\theta = 120° \pm 18°$, $r = 0.95$), four downy ($\theta = 281° \pm 78°$, $r = 0.40$) and five hairy ($\theta = 118° \pm 43°$, $r = 0.75$) woodpecker nests).

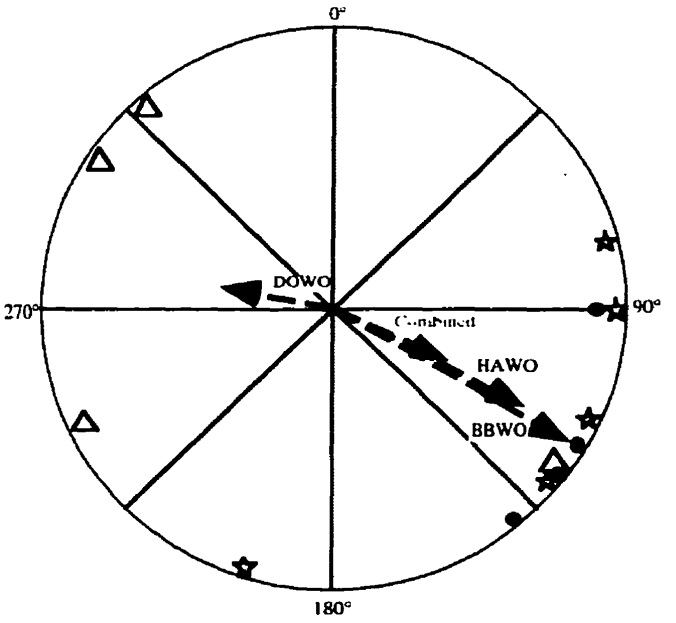
a)



= Mean cavity orientation ($\theta = 324° \pm 103°$, $r = 0.20$)

Prevailing wind

b)



= Mean nest orientation

△ downy woodpecker ★ hairy woodpecker ● black-backed woodpecker

Table 3-3. Mean nest-tree characteristics for four black-backed (BBWO), four downy (DOWO) and five hairy (HAWO) woodpecker nests in balsam fir forest, western Newfoundland. Means from Newfoundland are followed by mean and range of values recorded east of the Rocky Mountains.

	BBWO		DOWO		HAWO		Combined	
Nest variable	$\bar{x}$	(SD)	$\bar{x}$	(SD)	$\bar{x}$	(SD)	$\bar{x}$	(SD)
Nfld. nest-tree dbh (cm)	27.5	(2.6)	29.5	(12.3)	38.5	(6.1)	31.9	(8.8)
N. American mean	23.8[a]		33.4[b]		36.0[c]			
N. American range	[16.5 – 38.0]		[15.0 – 66.0]		[20.0 – 64.0]			
Nfld. nest height (m)	4.8	(1.0)	4.6	(1.2)	6.0	(1.5)	5.2	(1.3)
N. American mean	3.4		6.5		7.4			
N. American range	[1.1 – 10.0]		[1.0 – 17.0]		[1.8 – 19.8]			
Nfld. tree height (m)	9.8	(4.4)	8.1	(2.3)	11.0	(4.7)	9.7	(3.9)
N. American mean	10.4		9.7		14.2			
N. American range	[2.4 – 20.0]		[1.5 – 19.8]		[4.0 – 26.5]			

Sources:

[a] Mayfield 1958; Evans and Conner 1979 (citations within); Short 1982 (citations within); Morrison et al. 1983 (citations within); Spytz 1993; Montevecchi (unpubl. data)

[b] Conner et al. 1975; Evans and Conner 1979 (citations within); Stauffer and Best 1982; Morrison et al. 1983 (citations within); Runde and Capen 1987; Li and Martin 1991; Spytz 1993; Montevecchi (unpubl. data); Parker and Kimball (unpubl. data)

[c] Conner et al. 1975; Evans and Conner 1979 (citations within); Morrison et al. 1983 (citations within); Runde and Capen 1987; Li and Martin 1991; Spytz 1993; Montevecchi (unpubl. data); Parker and Kimball (unpubl. data)

Table 3-4. ANOVA summaries of the number of live and dead tree stems ≥ 10 cm dbh/ha and combined live and dead tree mean dbh for 0.04 ha plots, divided into 100 m^2 quadrants surrounding nest-trees (Quad.), and four point tallies each at 40 and 80 m from the nest-tree (Tran.), for black-backed (BBWO), downy (DOWO) and hairy (HAWO) woodpecker nests in western Newfoundland.

		Number of stems per hectare					DBH		
			Live		Dead			Live and Dead	
Nest	Source	*df*	*F*	*P*	*F*	*P*	*df*	*F*	*P*
BBWO	Quad.	3	1.18	0.36	0.109	0.95	3	1.14	0.37
	Error	12					13		
	Tran.	1	0.258	0.63	0.323	0.59	1	7.41	0.01
	Error	6					338		
DOWO	Quad.	3	0.652	0.60	0.026	0.99	3	1.30	0.33
	Error	12					10		
	Tran.	1	0.204	0.67	0.008	0.99	1	2.96	0.09
	Error	6					465		
HAWO	Quad.	3	0.274	0.84	0.291	0.83	3	1.83	0.16
	Error	16					37		
	Tran.	1	0.018	0.90	0.008	0.93	1	5.09	0.02
	Error	7					326		

There were no differences in the number of live or dead stems ≥ 10 cm dbh among the 40 and 80 m transect points for black-backed, downy, or hairy woodpeckers (Tran., Table 3-4). There was a difference of two dbh classes (4 cm maximum difference) for black-backed woodpecker and one dbh class (2 cm maximum difference) for hairy woodpecker nests for combined live and dead stem mean dbh between the 40 and 80 m tally points (Tran. mean dbh, Table 3-4). These differences were both in the small (10–18 cm) dbh class category and are probably irrelevant to woodpecker nesting behaviour. Therefore, for further analyses all

transect points were grouped to represent 'meso-scale' habitat, within 100 m of each woodpecker nest-site (the area referred to as "Tran.").

There were no differences in mean dbh or tree height between Block, Tran., or Nest areas for black-backed, downy or hairy woodpecker nests, so these areas were grouped by species as a representation of nest-habitat for comparison to different-aged balsam fir forests. There was a significant difference in crown closure between the Block ($\theta = 37 \pm 16\%$, $n = 13$) and Nest area ($\theta = 14 \pm 7\%$, $n = 4$) for black-backed woodpeckers (Table 3-5).

The only difference in the number of live tree stems was for the large (≥ 30 cm) dbh class, between Block ($\bar{x} = 23 \pm 16$ stems/ha) and Nest ($\bar{x} = 75 \pm 74$ stems/ha) areas for downy woodpeckers (Table 3-6). However, due to the high standard deviations it was difficult to conclude any actual biological significance to this statistical difference. Since there were no differences for live or dead stems ≥ 10 cm between Nest, Tran., or Block areas, this dbh category was used for macro-site comparisons between nest-sites and balsam fir forest structural characteristics.

There was a lower density of both live and dead stems ≥ 10 cm at black-backed, downy and hairy woodpecker nest-sites than in 40-, 60-, or 80⁺-year-old forests ($F_{6, 114} = 23.82$, $P \leq 0.0001$; LSD: $P \leq 0.001$ for live stems; $F_{6, 114} = 43.58$, $P \leq 0.0001$; LSD: $P \leq 0.001$ for dead stems; Figure 3-5).

The diameter of combined live and dead stems was greater at downy nest-sites than in 40-year-old stands, but only by one dbh class ($F_{6, 116} = 2.29$, $P = 0.04$; LSD: $P \leq 0.03$; Figure 3-6a). Height of combined live and dead trees at black-backed, downy and hairy woodpecker nest areas were all significantly shorter than found in 40-, 60-, and 80⁺-year-old balsam fir forests ($F_{6, 77} = 9.74$, $P \leq 0.0001$; LSD: $P \leq 0.02$; Figure 3-6b).

Crown closure at black-backed Nest and Block areas, and downy and hairy woodpecker combined areas were all significantly lower than found in 40-, 60-, and 80⁺-year-old forests ($F_{7, 82} = 21.0$, $P \leq 0.001$; LSD: $P \leq 0.01$) (Figure 3-6c).

Table 3-5. Diameter at breast height (dbh), crown closure (Canopy (%)), tree height, and age at breast height of grouped live and dead stems surrounding four black-backed (BBWO), four downy (DOWO) and five hairy (HAWO) woodpecker nests in balsam fir forest in western Newfoundland.

			dbh (cm)		Canopy (%)		Height (m)		Age (yrs)	
Species	**Area**	**(n)**	$\bar{x}$	**(±SD)**	$\bar{x}$	**(±SD)**	$\bar{x}$	**(±SD)**	$\bar{x}$	**(±SD)**
BBWO	Block	(13)	15.3	(5.7)	37	(16)	8.8	(3.0)	89	(38)
	Tran.	(8)	17.2	(6.5)	•	•	•	•		
	Nest	(4)	14.2	(4.7)	14	(7)	7.7	(2.3)	83	(6)
			$F_{2,22} = 0.41$		$F_{1,14} = 6.05$		$F_{1,14} = 0.56$			
			P = 0.66		P=0.03		P = 0.46			
DOWO	Block	(15)	18.2	(3.3)	38	(31)	9.1	(2.8)	84	(25)
	Tran.	(8)	21.4	(4.7)	•	•	•	•	•	•
	Nest	(4)	16.4	(4.4)	47	(5)	8.6	(1.3)	71	(6)
			$F_{2,25} = 2.74$		$F_{1,17} = 1.97$		$F_{1,15} = 0.04$			
			P = 0.08		P = 0.18		P = 0.84			
HAWO[a]	Block	(19)	17.1	(4.9)	39	(31)	10.7	(3.5)	64	(37)
	Tran.	(10)	14.0	(6.9)	•	•	•	•	•	•
	Nest	(5)	14.1	(5.4)	16	(25)	7.3	(3.9)	61	(11)
			$F_{2,30} = 1.19$		$F_{1,18} = 3.28$		$F_{1,15} = 3.57$			
			P = 0.32		P = 0.09		P = 0.08			

[a] High standard deviation for HAWO due to nests in a variety of sites from clearcuts to forest, therefore wide range in Canopy (%).

Table 3-6. Summary of ANOVAs for stem density and diameter, grouped by Nest-site, surrounding black-backed (BBWO), downy (DOWO) and hairy (HAWO) woodpecker nest sites in western Newfoundland.

			Number live stems/ha (cm class)								Number dead stems/ha (cm class)							
Species			10–18		20–28		≥30		≥10		10–18		20–28		≥30		≥10	
(n)	Area[a]	(n)	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD	$\bar{x}$	±SD
	Block	(12)	627	225	159	149	20	29	809	188[b]	190	128	49	38	10	15	276	178
BBWO	Tran.	(8)	491	359	131	93	23	33	644	335	185	217	51	34	13	20	248	221
(4)	Nest	(4)	430	398	106	82	6	13	542	306	119	87	62	94	13	14	193	159
	ANOVA		$F = 0.80$		$F = 0.31$		$F = 0.45$		$F = 1.82$		$F = 0.32$		$F = 0.11$		$F = 0.82$		$F = 0.16$	
	df = 2,21		$P = 0.46$		$P = 0.73$		$P = 0.65$		$P = 0.19$		$P = 0.73$		$P = 0.90$		$P = 0.92$		$P = 0.85$	
	Block	(15)	537	329	221	120	23	16*	788	370[c]	367	225	101	36	15	9	547	348
DOWO	Tran.	(8)	342	320	195	165	52	48	590	390	345	433	124	81	27	21	496	488
(4)	Nest	(4)	362	443	249	89	75	74*	685	422	330	414	106	55	13	25	449	458
	ANOVA		$F = 1.01$		$F = 0.24$		$F = 3.42$		$F = 0.64$		$F = 0.03$		$F = 0.47$		$F = 1.57$		$F = 0.03$	
	df = 2,24		$P = 0.38$		$P = 0.79$		$P = 0.05$		$P = 0.54$		$P = 0.98$		$P = 0.63$		$P = 0.23$		$P = 0.98$	
	Block	(19)	375	431	75	83	12	13	462	482	221	276	61	92	10	16	293	363
HAWO	Tran.	(10)	372	352	54	93	20	36	446	428	203	363	52	87	6	9	260	442
(5)	Nest	(5)	165	249	60	82	25	56	249	323	110	164	80	102	15	34	204	263
	ANOVA		$F = 0.62$		$F = 0.22$		$F = 0.51$		$F = 0.46$		$F = 0.29$		$F = 0.15$		$F = 0.52$		$F = 0.12$	
	df = 2,31		$P = 0.55$		$P = 0.81$		$P = 0.61$		$P = 0.64$		$P = 0.75$		$P = 0.86$		$P = 0.60$		$P = 0.89$	

[a] Nest = Structure immediately surrounding each nest site; Tran. = Sample points, four of each at 40 and 80 m from nest sites; Block = Four 6 ha blocks surrounding each nest site.

[b] (n) for Block = 13, df = 2,22; [c] (n) for Block = 16, df = 2,25; * Significantly different, LSD: $P = 0.03$

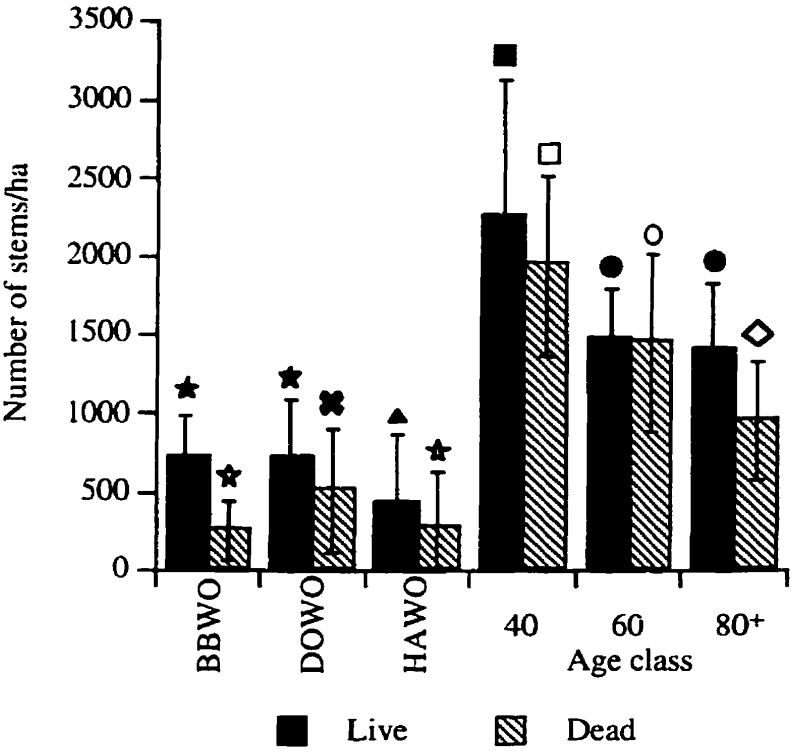
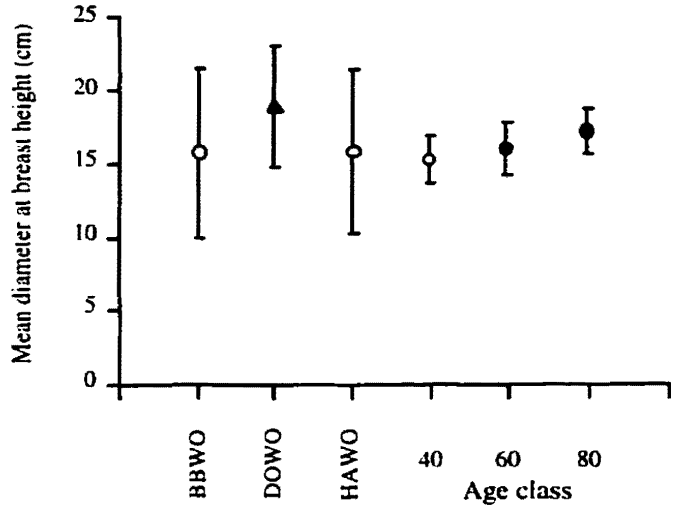


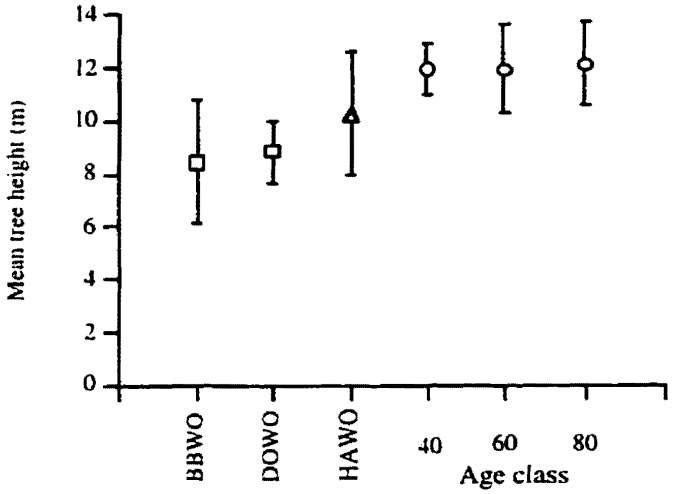
Figure 3-5. Mean number of standing live and dead stems ≥ 10 cm dbh for combined Block, Tran. and Nest areas for black-backed (BBWO), downy (DOWO) and hairy (HAWO) woodpecker nests, and for 40-, 60-, and 80⁺-year-old balsam fir stands in western Newfoundland. Bars topped by different symbols are significantly different between forest age classes and nest-sites (ANOVA, $P \leq 0.0001$; LSD, $P \leq 0.03$). Error bars represent ± 1 standard deviation. See text for respective sample sizes.

Figure 3-6. a) Mean diameter at breast height (mean dbh, in cm); b). tree height (m); and c) crown closure (%) for areas surrounding four black-backed (BBWO), four downy (DOWO) and five hairy (HAWO) woodpecker nests, and 10 sites each of 40-, 60- and 80*-year-old balsam fir forests in western Newfoundland. Different symbols represent significant differences (ANOVA, $P \leq 0.04$; LSD, $P \leq 0.03$). Symbols with solid fill patterns are not significantly different ($P \geq 0.05$). Error bars represent ± 1 standard deviation. 'Quad.' = four 100 m^2 quadrants surrounding nest-tree, 'Block' = four 6 ha blocks surrounding each nest-tree.

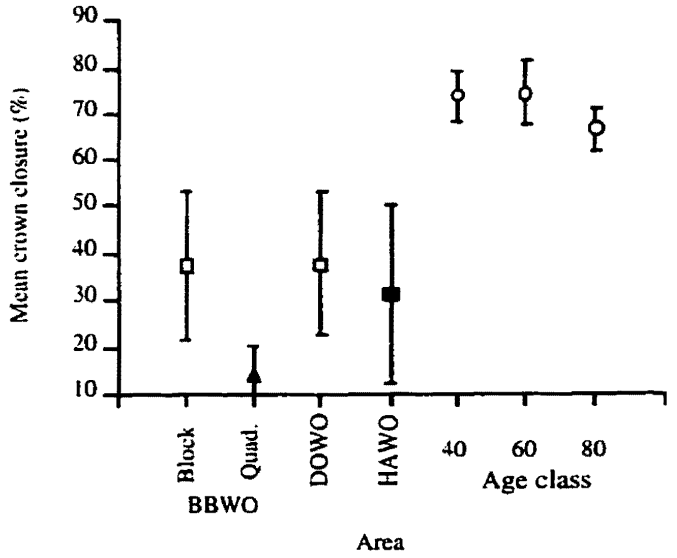
a)


Mean diameter at breast height (cm)
25
20
15
10
5
0
BBWO
DOWO
HAWO
40
60
80
Age class

b)


Mean tree height (m)
14
12
10
8
6
4
2
0
BBWO
DOWO
HAWO
40
60
80
Age class

c)


Mean crown closure (%)
90
80
70
60
50
40
30
20
10
Block
Quad.
DOWO
HAWO
40
60
80
Age class
BBWO
Area

3.4 DISCUSSION

A higher density of cavities in 80⁺- than in 40-year-old stands may indicate that older stands have accumulated more cavity trees. However an accumulation of old cavity trees is unlikely. Balsam fir snags (that accounted for the majority of cavity trees) remain sound for approximately five years in a stand following death by defoliation, and during that time disease, such as sapwood rot, will cause deterioration of the standing stem (Warren 1989). The fact that the mean dbh of cavity trees in 80⁺-year-old stands was greater than in the younger stands also provides evidence that the higher density of cavity trees is not an accumulation over time. This relationship of cavity density to stand age in balsam fir stands is unlike that in hardwood forests of West Virginia, where the abundance of cavity-trees was highly variable among similar forests and where much of the variability was unrelated to age, dbh, or other stand and topographic features (Carey 1983*a*). The greater cavity density in 80⁺-year-old forest indicated that while breeding woodpeckers were not necessarily found more frequently in older stands during breeding season point counts (see chapter 2), there appeared to be greater use of this older forest as nesting or roosting habitat.

Nest-tree mean dbh, height and nest height all fell within the range of similar data recorded throughout the eastern North American range for black-backed, downy and hairy woodpeckers (Conner et al. 1975; Short 1982; Stauffer and Best 1982; Morrison et al. 1983; Runde and Capen 1987; Hågvar et al. 1990; Li and Martin 1991; Spytz 1993). All nest-tree diameters were within the range of that found throughout the range of each species (Table 3-3). Mean nest height for black-backed woodpeckers appeared to be at the maximum for their recorded nest height from throughout their range, while nest-tree height was average. Newfoundland downy and hairy woodpecker nest and nest-tree heights are both 20–40% lower than the eastern North American average (Table 3-3). While there was no difference in cavity height among age classes, the greater height of cavity-trees in 80⁺- than 40-year-old stands suggested that woodpeckers chose larger trees within stands, as there were no differences in average tree height among age classes (Figure 3-6b). Although reproductive

benefits of higher cavity-nests are difficult to determine (Li and Martin 1991), one possible benefit may be that higher cavity-nests provide brood-tending cavity-nesters, or roosting adults and fledglings with more time to detect and divert approaching predators such as red squirrel (*Tamiasciurus hudsonicus*) or marten (*Martes americana*).

The random nest orientation found for downy woodpeckers was similar to what has been found for downy woodpecker nest-cavities constructed in artificial nest substrates (Peterson and Grubb 1983). It was also found that cavities constructed during the breeding season were oriented randomly and that cavities used for roosting during the winter faced away from the prevailing wind direction (Peterson and Grubb 1983). While this type of behaviour is likely for downy woodpeckers in Newfoundland balsam fir forests, it was impossible to determine if cavities were or are used for roosting or nesting. Black-backed, three-toed, downy and hairy woodpeckers showed a preference for constructing cavities in decayed wood. They located decayed portions on the stem and even altered the shape of a cavity to follow the pattern of decayed wood (Miller et al. 1979). Therefore nest height and orientation are likely limited primarily by decay patterns in the stem. Nest-tree diameters in the upper 5–25% of the dbh distribution indicated that nest-trees are standing stems that are residuals from past insect defoliation or blow-down events. Such trees are most likely to be removed under an even-aged management system.

Black-backed woodpeckers were the only species found at nest-sites (micro-habitat) with low canopy cover relative to meso- and macro-scale habitat measurements. Low canopy cover is associated with low stem density at the nest area. All three woodpecker species chose relatively open sites as nest-sites — typically less than 700 live stems/ha with 35–40% crown closure. This was a result of selection of recently disturbed areas, leaving many large diameter stems weakened and suitable for cavity construction. Selection of these open sites may be a trade-off to increased exposure to aerial predators (Li and Martin 1991). Remains of at least five hairy or downy woodpeckers were found at two sharp-shinned hawk (*Accipiter striatus*) plucking posts, one being within the area measured around one downy woodpecker nest-tree (J. Gosse, pers. comm.). The nest area stem density is approximately ½ half the number of

trees of the same diameter classes that would be found in a 60-year-old harvest rotation, that is, a density of approximately 1500 stems/ha.

Random events such as small-scale defoliation, wind-throw and tree suppression, with suitable nest-trees showing signs of decay seem to account for the majority of nest-sites found. Unfortunately, these are areas that current timber management methods attempt to eliminate through short rotations and insect spray programs. Depending on the future success of these management techniques, and the extent of forests subjected to short harvest rotations, suitable nest-sites may become rare in managed forests.

If nesting areas with low stem densities are a reproductive requirement for woodpeckers, as was observed here, then an extensive repeated 60-year harvest rotation will eliminate most woodpecker nesting habitat. A forest designed for timber production makes use of all available growing space. Tree growth is enhanced by pre-commercial thinning that will leave healthy softwood stems through to harvest period before volume loss due to blow-down or rot. Even-aged management at the scale that takes place in Newfoundland will particularly affect black-backed woodpeckers. That species showed a preference for the upper 5–25% of the dbh distribution of softwood nest-trees that are harvested for pulpwood. Downy and hairy woodpeckers seemed to be able to exist on the remnant white birch stems that are usually left undisturbed by pulpwood harvesters. Downy woodpeckers as well are able to nest in smaller diameter, decayed balsam fir snags that are found in younger age class forests.

4. FUTURE RESEARCH AND RECOMMENDATIONS FOR WOODPECKER HABITAT MANAGEMENT

Black-backed and three-toed woodpeckers are found consistently in the oldest conifer forest types available across a landscape. While there were no statistical differences in abundance among 40-, 60-, and 80-year-old balsam fir forests, there was a trend for the black-backed woodpeckers to be found more commonly in the oldest age classes available. The higher density of cavity-trees in older forests indicates long-term use of later successional stages of balsam fir forest. Cavity-trees and the nest-trees were in larger-diameter stems that were rarely found in younger balsam fir forests. Nest-sites were in relatively open areas typical of sites resulting from small insect defoliation outbreaks or blow-downs, conditions found in older balsam fir forests. These later successional stages will either be eliminated or extremely limited in a forest extensively managed for resource extraction.

It is difficult to provide an operational (applicable to management goals) definition of a cavity-tree (Carey 1983*a*). There is, however, enough information to provide *timber* managers with the necessary information to allow them to manage for suitable woodpecker habitat, thus making for more robust *forest* management. Managers should focus on landscape and ecosystem features that affect woodpecker populations and distribution, rather than on requirements for a minimum viable population (Probst and Crow 1991). Perhaps the most effective method to ensure that there is ample supply of black-backed nest-habitat is to exempt some areas from commercial or post-insect defoliation salvage-harvest (Goggans et al. 1988; Montevecchi and Bouman 1993).

The eradication of older successional stages of the balsam fir forest could potentially threaten the integrity of black-backed woodpecker habitat, and thus the persistence of black-backed woodpecker populations in Newfoundland. There is no firm scientific evidence showing that there is a causal link between low woodpecker populations and the regulation of age structures of balsam fir forests to the exclusion of later successional stages. We should approach future forest management using the precautionary principle (Gray 1990; Peterman

and M'Goingle 1992). Managers should assume that eradication of older balsam fir forests affects woodpecker populations and habitat, and therefore should plan for inclusion of these stands at the landscape-level to avoid ecosystem deterioration and habitat loss (Thompson and Welsh 1993).

Future research is needed only to improve the precision of the definition of habitat selection by woodpeckers. For management purposes, the one remaining important question is that of patch size and patch distribution. This question can be answered by studying factors such as dispersal distance of juveniles. In order to determine the degree of potential competition for dispersing juveniles, an assessment of population density over a large scale of habitat and age class distributions throughout the balsam fir forest will be necessary. Dispersal of juveniles is relatively unstudied for most species. Downy woodpeckers move outside the territory from which they were hatched (Short 1982). Dispersal and displacement or establishment of new territories are no doubt critical times in the life cycles of woodpeckers. Therefore an understanding of the spatial arrangement of suitable habitat on a landscape scale is essential to understanding woodpecker ecology and for providing effective management of woodpecker habitat (Dunning et al. 1995; Turner et al. 1995). Woodpeckers need large areas with old-growth properties because of their relatively large body size, but they may be able to use a set of small patches supplemented by nearby resource patches of similar quality (Dunning et al. 1992; Angelstam and Mikusinski 1994). Therefore, it is necessary to develop studies of sufficient duration (7–10 years) and on a scale that can provide reliable information of age of reproduction, survival rates, and juvenile dispersal and turnover (Verner 1992).

Forest growth projection modelling tied in with life requirements of black-backed woodpeckers will allow predictions of the potential amount and distribution of suitable black-backed woodpecker habitat through time in a forest with large-scale management interventions. The association of cavity-excavating birds and tree disease is well documented (Conner et al. 1976), so the incidence of disease in a stand, such as heart-rot, could be an important factor to include in such models. Relating the incidence of, and susceptibility to,

heart-rot based on forest site types could be one valuable tool for spatial prediction of nest-habitat areas.

An incorporation of forest growth projection models through time and space and identification of the parameters resulting in incidence of heart-rot will provide insight for cavity-nest habitat management. This will only be possible when there is a suitable forest inventory and growth curves developed for all balsam fir forest types in Newfoundland. This type of information will aid timber managers in planning for habitat availability where only a narrow time margin provides suitable woodpecker habitat, because the forests are relatively short-lived. This will undoubtedly begin with a more thorough and accurate inventory and development of forest growth projections for western Newfoundland, and will require a commitment to long-term support for demographic studies and habitat dynamics for primary cavity-nesters in a short-lived balsam fir ecosystem.

If wildlife ecologists are to provide advice to timber managers of the potential effects of management strategies on the environment, manipulative experiments where amounts and types of selected habitat are varied and species responses monitored are needed. Another approach is to develop or improve models that include habitat selection processes to predict habitat distributions and population growth (Peters 1991). These are invaluable tools for predicting effects of habitat manipulations on natural populations.

Forest management decisions on a landscape-scale must include quantifications of and predictions about wildlife habitat and habitat quality. Managers must use accurate measurements of habitat quality and make comparisons between habitat types before defining management options. It has become increasingly important to define the biological or ecological importance of particular habitats. It is imperative that managers consider demographic measurements and relate them to habitat variables in order to better adjust their manipulations of the environment. If *timber* managers are to become more effective *forest* managers, they need to gain an understanding of the short- and long-term effects of their interventions in an ecosystem.

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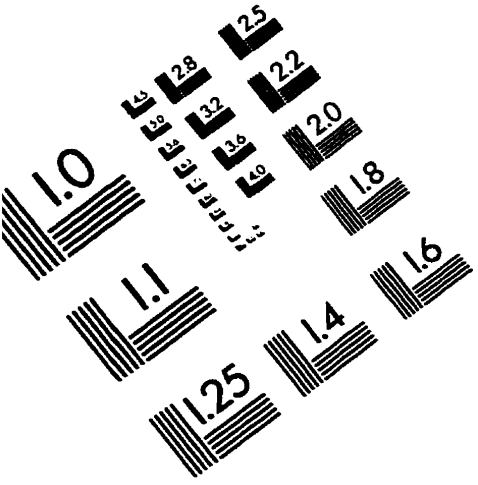
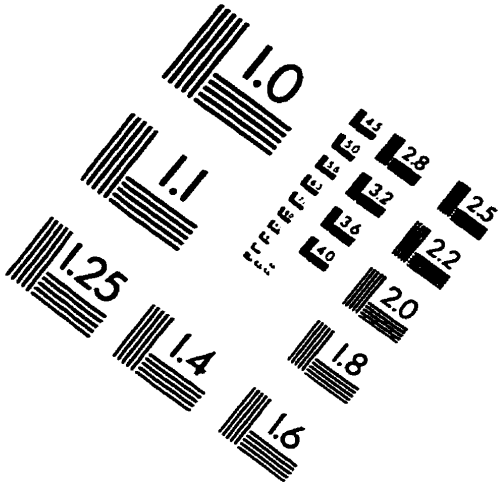
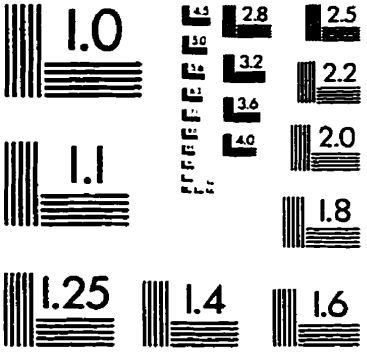
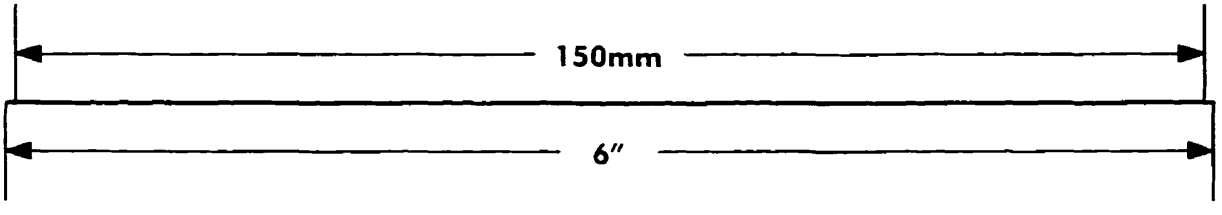
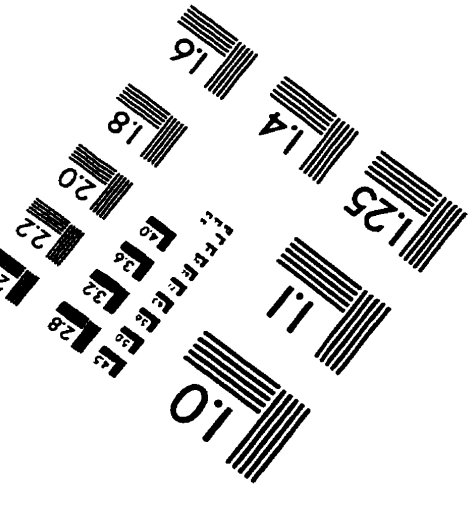
IMAGE EVALUATION
TEST TARGET (QA-3)

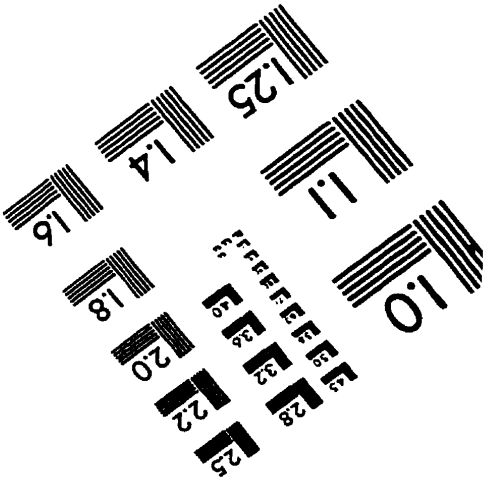












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